LONG-TERM CONTRACTS, RATIONAL EXPECTATIONS AND TRADE BALANCE DYNAMICS

BY

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LONG-TERM CONTRACTS, RATIONAL EXPECTATIONS AND TRADE BALANCE DYNAMICS

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The literature of trade balance dynamics has focused on short-run and long-run analyses and has ignored the intermediate run. Actually, however, the intermediate run constitutes a major part of the dynamic adjustment process after unanticipated shocks. In this study, two rational expectations models incorporating long-term trade contracts and labor contracts are developed. They allow the relative price and income effects on the trade balance (the parameters on the demand side) and the renewal rates of labor contracts (the parameter on the supply side) to change over time, thus making possible an intermediate-run analysis as well as short-run and long-run analyses.

The first model generates a rich variety of gradual and nonmonotonic adjustment paths for the trade balance after an unanticipated devaluation under fixed exchange rates. It also shows that the low expected relative price effect in the initial periods can prolong the duration of J-curve effects which are created by the unanticipated devaluation. If J-curve effects dominate the real interest rate effect in the short run, the devaluation has a contemporaneously contractionary effect on output.

The second model examines the adjustment process after an unanticipated increase in the money supply under flexible exchange rates. It proves that significant J-curve effects on the trade balance can cause a contemporaneous countershooting or undershooting of the exchange rate. Furthermore, in the short run,the countershooting can reverse J-curve effects on the trade balance, enlarge the expansionary effect on output and increase the interest rate. The trade balance reaches its highest position in the short run due to the reversal of J-curve effects. After that, in the intermediate run, the trade balance decreases gradually below the initial level before it returns to the long-run level. The whole adjustment process for the economy is very different from the process after a devaluation under fixed exchange rates.

CHAPTER 1
INTRODUCTION

1.1 The Purpose of this Research

In the literature, almost all the parameters in most rational expectations models are assumed to be fixed over time. As a result, these models can perform short-run and long-run analyses but not intermediate-run analysis. Actually, however, the intermediate run constitutes a major part of the dynamic adjustment process after unanticipated shocks. Consequently, there is a significant gap in the literature. This dissertation fills this gap by incorporating both long-term trade and labor contracts into rational expectations models. The long-term labor contracts are of the type discussed in Fischer (1977) but the long-term trade contracts are new concepts not yet explored in the area of international economics. Our models also allow the relative price and income effects on the trade balance (the parameters on the demand side) and the renewal rates of labor contracts (the parameter on the supply side) to change over time. Therefore, a significant feature of the models studied in this dissertation is their ability to analyze the intermediate run as well as the short run and the long run.

1.2 An Outline of the Dissertation

In Chapter 2, we introduce the concept of long-term trade contracts. A rational expectations model incorporating long-term trade and labor contracts and J-curve effects on the trade balance generates a rich variety of gradual and nonmonotonic adjustment paths for the trade balance after an unanticipated devaluation under fixed exchange rates. It also shows that the low expected relative price effect in the initial periods can prolong the duration of J-curve effects which arise from the unanticipated devaluation. If the J-curve effects dominate the expected real interest rate effect in the short run, the devaluation has a contemporaneously contractionary effect on output. Two special cases without long-term trade contracts are derived from the general model. Although they may be justified from the viewpoint of the long run and the short run, they fail to account for the intermediate run. The most likely path for the trade balance generated from the model is as follows: after an initial decline for one or two periods, the trade balance could improve gradually and continuously for the next two or three periods, then decline during the last two or three periods toward the initial level.

Under the alternative regime of flexible exchange rates, the exchange rate is a main channel through which the effects of money supply spread to the entire economy. Therefore, we shall investigate in Chapter 3 the exchange rate dynamics after an unanticipated increase in money supply under flexible exchange rates, leaving a discussion of the trade balance dynamics to Chapter 4. In this chapter, we prove that J-curve effects on the trade balance may cause a contemporaneous countershooting or undershooting of the exchange rate following an unanticipated monetary disturbance. The most likely time path of the exchange rate generated from the model is the following: countershooting in the short run, undershooting in period two, overshooting for the next two periods, then undershooting for the last two periods.

In Chapter 4, we examine the trade balance dynamics after an unanticipated monetary disturbance under flexible exchange rates. Chapter 4 continues Chapter 3, using the same model. Under flexible exchange rates, the trade balance reaches its highest position in the first period due to the reversal of J-curve effects. After that, in the intermediate run, the trade balance decreases gradually below the initial level before it returns to the long-run level. Three special cases are derived from the model, one of which is the Dornbusch model (1976). In addition, six numerical examples are simulated to illustrate the predictions of the model.

Finally, Chapter 5 presents the conclusions of this study.

CHAPTER 2
UNANTICIPATED DEVALUATIONS AND TRADE BALANCE DYNAMICS UNDER FIXED EXCHANGE RATES

2.1 Introduction

Recently, the existence of a phenomenon which has been called the J-curve effect after currency devaluations has been recognized and incorporated into the theory of the trade balance. The term J-curve refers to an immediate decline and subsequent improvement in the trade balance following a devaluation. The J-curve result ensues if the proportion of trade contracts denominated in foreign currency is higher for imports than for exports.

The simplest model of a J-curve effect, devised by Williamson (1972), involves a one-period lag in the effect of the nominal exchange rate on trade volumes and an unlagged effect of the nominal exchange rate on the import price. He wrote the trade balance equation as

$$T_t = -a_3 e_t + \bar{a}_4 e_{t-1} \qquad (2.1)$$

where T_t is the domestic trade balance (not in log); e_t denotes the logarithm of the value of the foreign currency in terms of the domestic currency; and $\bar{a}_4$ exceeds a_3 by virtue of the Marshall-Lerner condition.[1]

Driskill and McCafferty (1980) incorporated rational expectations in equation (2.1) by replacing e_{t-1} with ${}_{t-1}e_t$, the nominal exchange rate of time t expected at time t−1. In both equation (2.1) and the modified version of Driskill and McCafferty, the nominal exchange rate effect on the trade balance remains constant after the first period. Furthermore, the nominal instead of the real exchange rate or relative price affects trade flows.[2] In a subsequent paper, Driskill (1981a) emphasizes the real exchange rate by replacing (2.1) with

$$T_t = -a_3(e_t - p_t) + \bar{a}_4({}_{t-1}e_t - {}_{t-1}p_t) \qquad (2.2)$$

where p_t is the logarithm of the domestic price level, and the foreign price level is normalized to one. But equation (2.2) retains a flaw, namely that all international traders are assumed to have trade contracts with a one-period delivery lag. Consequently, the relative price elasticity of the trade balance is constant over time, and the model incorporating equation (2.2) can generate only a simple, instantaneous and monotonic adjustment process for the trade balance in the intermediate run.

But Tables D.1, D.2 and D.3 in Appendix D show that the devaluations of the Korean won in December 1974, the British pound sterling in November 1967 and the Nepalese

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rupee in October 1975 brought about complex, gradual and nonmonotonic time paths for their trade balances.[3] In order to explain this phenomenon, we have to devise a more sophisticated trade balance equation, one that recognizes that different traders have trade contracts with varying delivery lags. For instance, the delivery lags for US imports from Japan in 1973 were 43 days for calculators, 89 days for auto parts, 52 days for motorcycles and and 176 days for steel.[4] Hence, different traders may form their expectations about current relative price and real income with different lead times.

Suppose we divide international traders into several groups according to their delivery lags. In each period, each group accounts for some part of the total volume of trade. The trade balance equation incorporating the overlapping trade contracts becomes

$$T_t = -a_3(e_t - p_t) + \sum_{i=1}^{N} a_{3+i}({}_{t-i}e_t - {}_{t-i}p_t) - \sum_{i=1}^{N} a_{3+N+i}\ {}_{t-i}y_t \qquad (2.3)$$

where y is output level (not in log) and N is the total number of groups with different delivery lags, and a_{3+i} and a_{3+N+i} are the expected real exchange rate and income effects on the trade balance respectively for the trader group with a delivery lag of i periods.

This chapter constructs a rational expectations model with overlapping trade and labor contracts that generates gradual and nonmonotonic adjustment paths for the trade balance after an unanticipated devaluation. For instance, after an initial decline for one or two periods, the trade balance might improve gradually and continuously for the next two or three periods, then declines for the last two or three periods to approach the initial level. A significant feature of the model is its ability to analyze the intermediate run.

In the next section, the model is set up. Section 2.3 presents the solutions of the model and compares the solutions with those of two special cases without overlapping trade contracts. Section 2.4 gives four numerical simulations. Conclusions are contained in section 2.5.

2.2 The Model

In our model, a small open economy faces a given world interest rate and a perfectly elastic supply of imports at prices given in terms of a foreign currency. The trade balance equation incorporates overlapping trade contracts in goods markets. Domestic and foreign bonds are assumed to be perfect substitutes and capital is perfectly mobile in asset markets. On the supply side, a simple price equation, relating prices to expected wages and output, and overlapping six-period wage contracts are used to reflect short-run price and wage rigidity.

2.2.1 The Goods Markets

A key difference between our model and those in the recent literature, such as Driskill (1981a) and Ueda (1983), is the assumption that different agents form expectations with different lead times rather than just one period ahead. The difference arises from the assumed length of the delivery lag for trade contracts. In the recent literature, all trade contracts are assumed to have a one-period delivery lag, but our model considers trade contracts with various delivery lags.

The concept of trade contracts, mentioned in the introductory section, is one of the main points in this paper and warrants a more detailed explanation. In Driskill (1981a), J-curve effects stem from equation (2.2). That is, the trade balance at time t is assumed to be a linear function of the log of the relative price at time t and of the conditional expectation taken at time t-1 of the log of the relative price at time t. The assumption that the current trade balance depends on prior expectations of current relative prices captures the idea that there are lags in the production process and consumption decision regarding exports and imports. But equation (2.2) has two shortcomings. The first is the absence of a clear distinction between the short-run and long-run reactions to changes in relative prices. For instance, $\bar{a}_4$ is assumed constant over time. The Marshall-Lerner condition is assumed to hold, which implies $\bar{a}_4 > a_3$. But the reactions of imports and exports to changes in relative prices tend to be small in the short run and large in the long run, suggesting that the condition is more likely to hold in the long run than in the short run.

The second shortcoming, already mentioned in the introductory section, is that all trade contracts are assumed to have the same delivery lag and all traders to form their expectations about current relative prices and income in the previous period. In reality, however, different agents form their expectations with different lead times. Some may form their expectations two periods earlier, others three periods earlier, and so on. The lead time depends on the length of their trade contracts, or what Magee (1973) called the currency-contract period. According to Magee (1973), the trade-contract period is the period immediately following a devaluation in which contracts negotiated prior to the change fall due. For importers, the length of the period between the ordering of foreign merchandise and its delivery at the port of entry can be divided into three lags: the production lag, the transportation lag and the entry lag. The production lag is the period between acceptance of an order and export. The transportation lag is the period between the date of exportation and the date of importation. Finally, the entry lag is the lag between the date of importation and the date of entry.[5]

Using an invoice sample of US imports from Japan and West Germany for 1971 and 1973, Magee (1974) calculated the three lags in the trade-contract period; the average and median lags by product are shown in Table 2.1 for Japan and Table 2.2 for West Germany. The total trade-contract period for US imports from Japan tended to be short for calculators, car parts and motorcycles. The longest was for steel. In the case of West Germany, the longest lag was for machine tools.

Tables 2.1 and 2.2 show that traders of different industries have different delivery lags. It is natural that different traders would form their rational expectations with different lead times. For instance, the delivery lag for German machine tools was 259 days on average and the trade contracts were denominated in marks. United States importers of machine tools had to form their expectations about the dollar/mark exchange rate and their income at least 259 days ahead. Similarly, because the average delivery lag for Japanese calculators was 74 days, US importers of calculators had to form their expectations for the next 74 days about the dollar/yen exchange rate and their income. If they expected the

Table 2.1. Mean and Median Lags in the Currency-Contract Period, US Imports from Japan, Fiscal Years 1971 and 1973 (Days: mean in standard numerals, median in parentheses).

	1971				1973				Total, 1971 and 1973			
Commodity	Production	Transportation	Entry	Total	Production	Transportation	Entry	Total	Number of observations	Total lag	Standard deviation	Skewness[a]
Organic chemicals	52 (14)	25 (33)	5 (7)	83 (45)	111 (59)	27 (27)	10 (8)	149 (90)	13	124 (89)	100	1.6
Tires	83 (34)	39 (14)	3 (2)	126 (129)	44 (22)	22 (27)	22 (26)	89 (67)	13	103 (67)	57	0.7
Plywood	101 (86)	25 (23)	8 (6)	134 (114)	80 (92)	14 (9)	17 (14)	112 (116)	11	124 (116)	67	0.4
Cotton fabrics	148 (157)	25 (25)	2 (1)	177 (180)	124 (121)	11 (8)	11 (10)	147 (127)	20	161 (145)	83	1.0
Synthetic fabrics	131 (125)	22 (23)	5 (3)	159 (153)	111 (83)	23 (23)	18 (20)	153 (117)	18	157 (133)	109	1.9
Steel plates & sheets	172 (124)	40 (41)	11 (10)	224 (185)	110 (79)	52 (51)	13 (12)	176 (158)	53	207 (116)	129	1.9
Calculators	139 (57)	5 (0)	7 (8)	151 (74)	32 (34)	2 (0)	8 (8)	43 (42)	14	74 (48)	101	3.1
Radios	88 (18)	12 (13)	18 (22)	118 (48)	93 (67)	18 (21)	14 (16)	126 (100)	21	122 (90)	93	0.7
Cars	76 (75)	21 (25)	11 (12)	109 (108)	60 (60)	20 (14)	20 (18)	100 (92)	32	106 (106)	24	0.4

Table 2.1--continued.

	1971				1973				Total, 1971 and 1973			
Commodity	Production	Transportation	Entry	Total	Production	Transportation	Entry	Total	Number of observations	Total lag	Standard deviation	Skewness[a]
Car parts	32 (10)	4 (0)	10 (9)	46 (17)	57 (44)	17 (15)	15 (16)	89 (86)	28	71 (60)	65	2.3
Motorcycles	34 (29)	24 (23)	15 (7)	73 (69)	34 (31)	10 (0)	7 (6)	52 (62)	7	65 (64)	30	0.3
Bicycles	47 (46)	36 (36)	0 (0)	84 (85)	154 (130)	22 (12)	13 (11)	190 (190)	11	152 (98)	97	1.7
Phonographs and tape recorders	96 (85)	20 (18)	3 (4)	120 (108)	67 (67)	14 (15)	13 (16)	96 (95)	12	108 (106)	58	0.2
All other goods	83 (54)	29 (28)	8 (9)	120 (85)	131 (125)	20 (20)	16 (10)	168 (160)	49	149 (132)	94	1.3
Total[b]	89 (79)	26 (26)	9 (9)	125 (116)	103 (66)	21 (20)	15 (14)	141 (113)	302	136[c] (116)	101	2.0

Source: Magee (1974), p. 132.

a. This measure of skewness is the standardized third moment of the sample distribution.

b. All means in this row, except that for the lag for the total of the two years, are weighted by the shares of the products in total US imports.

c. This is not a weighted mean.

Table 2.2. Mean and Median Lags in the Currency-Contract Period, US Imports from West Germany, Fiscal Years 1971 and 1973 (Days: mean in standard numerals, median in parentheses).

Commodity	1971				1973				Total, 1971 and 1973			
	Production	Transportation	Entry	Total	Production	Transportation	Entry	Total	Number of observations	Total lag	Standard deviation	Skewness[a]
Organic chemicals	99 (120)	24 (11)	5 (3)	129 (160)	82 (46)	11 (12)	7 (5)	100 (64)	15	110 (76)	81	1.5
Dyes	-- (--)	-- (--)	-- (--)	-- (--)	49 (25)	16 (21)	11 (11)	77 (57)	9	77 (57)	49	0.9
Tires	58 (76)	3 (0)	14 (12)	76 (107)	120 (76)	14 (12)	14 (18)	149 (110)	9	125 (107)	108	0.9
Textile yarn	79 (91)	11 (10)	13 (13)	104 (111)	115 (132)	18 (16)	14 (20)	148 (161)	9	119 (118)	62	0.4
Steel plates & sheets	118 (94)	21 (18)	11 (11)	151 (133)	112 (103)	21 (24)	13 (11)	146 (139)	46	148 (136)	87	2.1
Engines	43 (49)	8 (12)	2 (3)	54 (64)	40 (40)	9 (9)	14 (14)	63 (63)	5	58 (64)	24	-0.8
Machine tools	317 (317)	6 (6)	4 (4)	328 (328)	218 (177)	25 (23)	14 (12)	258 (217)	6	259 (194)	194	0.5

Table 2.2--continued.

	1971				1973				Total, 1971 and 1973			
Commodity	Production	Transportation	Entry	Total	Production	Transportation	Entry	Total	Number of observations	Total lag	Standard deviation	Skewness[a]
Textile machinery	107 (42)	11 (6)	8 (8)	127 (61)	107 (38)	7 (11)	15 (17)	129 (47)	15	121 (46)	129	1.0
New cars	11 (11)	12 (12)	7 (7)	30 (30)	8 (2)	18 (16)	7 (6)	33 (30)	18	32 (30)	15	1.6
Car parts	49 (35)	6 (1)	13 (5)	69 (55)	111 (56)	9 (9)	18 (19)	138 (83)	13	101 (65)	108	1.9
All other goods	163 (162)	7 (1)	9 (9)	181 (169)	61 (62)	11 (10)	17 (11)	93 (95)	27	135 (106)	117	2.0
Total[b]	99 (87)	10 (12)	8 (10)	111 (103)	52 (48)	14 (15)	31 (11)	81 (84)	173	120[c] (84)	107	1.9

Source: Magee (1974), p. 133.

a. This measure of skewness is the standardized third moment of the sample distribution.

b. All means in this row, except that for the lag for the total of the two years, are weighted by the shares of the products in total US imports.

c. This is not a weighted mean.

dollar to devalue or their income to decrease within the delivery lag of their imports, they may have decreased the size of their orders or canceled them. The resulting decrease in imports improved the US trade balance. That implies that the coefficients a_4 through a_9 are positive but a_{10} through a_{15} are negative.

Tables 2.1 and 2.2 were calculated by Magee from the data taken from a one percent sample of the US customs invoices for imports from Japan and West Germany in the fiscal years 1971 and 1973. Therefore, the results from Tables 2.1 and 2.2 need not hold for all imports or for different periods. One should not be surprised by longer or shorter delivery lag than those in Tables 2.1 and 2.2 if another sample were used instead.

Having discussed the concept of trade contracts, we apply it to the aggregate demand function. The aggregate demand for domestic goods is the sum of the spending on domestic goods by domestic and foreign residents. Alternatively, it can be written as the sum of aggregate spending by domestic residents and the trade balance.

Aggregate spending by domestic residents depends negatively on the real interest rate and positively on real income because expenditure by investors is a decreasing function of the real interest rate and spending by consumers is an increasing function of real income. Hence, aggregate spending by domestic residents is given by the equation

$$a_0 - a_1(i_t - {}_tp_{t+1} + p_t) + a_2y_t$$

where a_1 and a_2 are positive constants, and i_t is the domestic nominal interest rate at time t.

For the trade balance, we use equation (2.3), incorporating the concept of trade contracts, and set N arbitrarily equal to six. Hence, the trade balance, measured in terms of the domestic currency, is given by the equation

$$T_t = -a_3(e_t - p_t) + \sum_{i=1}^{6} a_{3+i}({}_{t-i}e_t - {}_{t-i}p_t) - \sum_{i=1}^{6} a_{9+i}\ {}_{t-i}y_t \qquad (2.4)$$

The log of the foreign price level is suppressed because it is assumed to equal zero by normalization. The term $e_t - p_t$ measures the contemporaneous relative price of domestic goods so that $a_3(e_t - p_t)$ reflects contemporaneous J-curve effects on the trade balance. The term ${}_{t-i}e_t - {}_{t-i}p_t$ measures the anticipated relative price of domestic goods expected at time t-i. Although setting N equal to six is arbitrary, six periods are long enough to allow the trade balance to adjust gradually and nonmonotonically, which permits us to do an intermediate-run analysis.

The values of the coefficients a_i depend on how early the agents form their expectations and the relationship between imports and exports and expectations. Generally, a_4 and a_5 may be greater than a_7 and a_8, and a_{10} may exceed a_{15}. In addition, we assume in equation (2.5) that all contracts for international transactions are written in terms of producers' currencies.[6] Therefore, the trade balance is affected by a currency devaluation only through the valuation of imports.[7] Hence, the goods market equilibrium condition is given by the equation

$$y_t = a_0 - a_1(i_t - {}_tp_{t+1} + p_t) + a_2 y_t - a_3(e_t - p_t) + \sum_{i=1}^{6} a_{3+i}({}_{t-i}e_t - {}_{t-i}p_t) - \sum_{i=1}^{6} a_{9+i}\, {}_{t-i}y_t \qquad (2.5)$$

2.2.2 The Assets Markets

Since real money demand depends positively on real income and negatively on the rate of interest, the demand for money is assumed to have the form

$$(m_t)^d - p_t = b_0 + b_1 y_t - b_2 i_t \qquad (2.6)$$

where m_t is the log of the money supply, and b_1 and b_2 are positive constants. Domestic asset holders are assumed to

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demand domestic money, and domestic and foreign bonds. The money supply is fully endogenous under fixed exchange rates. Monetary equilibrium is described in equation (2.7) by the equality of the real money stock $m_t - p_t$ and the demand for real money balances:

$$m_t - p_t = b_0 + b_1 y_t - b_2 i_t \qquad (2.7)$$

Domestic and foreign bonds are assumed to be perfect substitutes given a proper premium to offset anticipated exchange rate changes. If the domestic currency is expected to depreciate, domestic interest rates will exceed those abroad by the expected rate of depreciation. That relationship is expressed in (2.8).

$$i_t = i^* + {}_t e_{t+1} - e_t \qquad (2.8)$$

where i^* is the given world interest rate. Equation (2.8) represents perfect capital mobility and it is assumed that incipient capital flows will ensure that equation (2.8) holds at all times. Furthermore, equation (2.8) implies that the domestic nominal interest rate is tied to the world interest rate through expected exchange rate changes. The domestic interest rate is lower than the world interest rate when an appreciation is anticipated and higher when a devaluation is expected. Under fixed exchange rates, as long as the current exchange rate is expected to continue, i.e., ${}_{t}e_{t+1} = e_t$, the domestic interest rate equals the foreign interest rate. As our objective is to emphasize the role of expectations in a devaluation, however, the interest rate parity condition is appropriately described by equation (2.8), even though in any given period e_t may not change.

Under fixed exchange rates, the exchange rate is exogenous. Assume the authorities set the exchange rate on the basis of disturbances which have occurred up to and including period t:

$$e_t = \sum_{i=0}^{\infty} v_{t-i} \qquad (2.9)$$

where the random terms v's are white noise processes with variances σ_v^2; the v's are permanent disturbances. Equation (2.9) could be made more general by allowing the coefficients of the random shocks to differ. This would permit us to analyze the J-curve phenomenon in a more general environment, but it would not alter any of the essential conclusions of this chapter.

2.2.3 Price and Wage Equations

In order to reflect short-run price rigidity, the supply side of the economy is represented by a simple price equation in which current prices relate positively to anticipated wages and the GNP gap. The equation for this is

$$p_t = {}_{t-1}w_t + d({}_{t-1}y_t - \bar{y}) \qquad (2.10)$$

where w is the log of the level of the nominal wage, $\bar{y}$ is potential output and d is an adjustment coefficient. In equation (2.10), p_t is predetermined because ${}_{t-1}y_t$ and ${}_{t-1}w_t$ are anticipated. Anticipated output, ${}_{t-1}y_t$, is demand determined by equation (2.5). When the aggregate demand for domestic goods is anticipated to increase, anticipated output increases and the price level increases too. Since the left-hand side of equation (2.10) is based on information available at time t-1, the contemporaneous p_t is unchanged when a devaluation occurs at time t. That is, p_t does not respond to any information available in period t because of the price rigidity. Ueda (1983) makes the same assumption. Further, the assumption can incorporate the main idea behind Dornbusch (1976) that goods markets adjust relatively slowly.

In equation (2.10), ${}_{t-1}w_t$ relates to the wage setting, or labor contracts of Fischer (1977). If firms renew labor contracts every six periods, and if the goal of nominal wage setting is to maintain constancy of the real wage, then

$$ {}_{t-i}w_t = z + {}_{t-i}p_t, \quad i = 1,\ldots,6. \qquad (2.11)$$

where ${}_{t-i}w_t$ is the log of the wage set at the end of period t-i for period t and z is a scale factor in the determination of the real wage and will be set at zero for convenience.

Suppose the labor contracts drawn up at the end of period t specify nominal wages for periods from t+1 to t+6. In period t, c_i percent of the agents operate in the ith year of a labor contract drawn up at end of t-i. The average wage for the economy as a whole at t is

$$ w_t = \sum_{i=1}^{6} c_i \; {}_{t-i}p_t, \qquad \sum_{i=1}^{6} c_i = 1, \qquad c_i > 0 \qquad (2.12)$$

The purpose of choosing six periods for labor contracts is to match setting N to six for trade contracts.[8]

To summarize, the following set of equations describes the economy:

$$ y_t = a_0 - a_1(i_t - {}_tp_{t+1} + p_t) + a_2y_t - a_3(e_t - p_t)$$

$$ + \sum_{i=1}^{6} a_{3+i}({}_{t-i}e_t - {}_{t-i}p_t) - \sum_{i=1}^{6} a_{9+i} \; {}_{t-i}y_t \qquad (2.5)$$

$$ m_t - p_t = b_0 + b_1y_t - b_2i_t \qquad (2.7)$$

$$ i_t = i^* + {}_te_{t+1} - e_t \qquad (2.8)$$

$$e_t = \sum_{i=0}^{\infty} v_{t-i} \tag{2.9}$$

$$p_t = {}_{t-1}w_t + d({}_{t-1}y_t - \bar{y}) \tag{2.10}$$

$$w_t = \sum_{i=1}^{6} c_i \, {}_{t-i}p_t, \quad \sum_{i=1}^{6} c_i = 1, \quad c_i > 0 \tag{2.12}$$

2.3. The Solution of the Model

Using Muth's (1961) method of undetermined coefficients in the time domain using moving averages, we solve the model. The solutions for the time paths of output, the price level, the money supply, the wage rate, the interest rate and the trade balance are

$$y_t = y_0 + \alpha_1 v_t + \alpha_2 v_{t-1} + \alpha_3 v_{t-2} + \alpha_4 v_{t-3} + \alpha_5 v_{t-4} + \alpha_6 v_{t-5} \tag{2.13}$$

$$p_t = p_0 + \beta_2 v_{t-1} + \beta_3 v_{t-2} + \beta_4 v_{t-3} + \beta_5 v_{t-4} + \beta_6 v_{t-5} + \sum_{i=6}^{\infty} v_{t-i} \tag{2.14}$$

$$m_t = m_0 + \gamma_1 v_t + \gamma_2 v_{t-1} + \gamma_3 v_{t-2} + \gamma_4 v_{t-3} + \gamma_5 v_{t-4} + \gamma_6 v_{t-5} + \sum_{i=6}^{\infty} v_{t-i} \qquad (2.15)$$

$$w_t = p_0 + k_2 v_{t-1} + k_3 v_{t-2} + k_4 v_{t-3} + k_5 v_{t-4} + k_6 v_{t-5} + \sum_{i=6}^{\infty} v_{t-i} \qquad (2.16)$$

$$i_t = i^* \qquad (2.17)$$

$$T_t = T_0 + g_1 v_t + g_2 v_{t-1} + g_3 v_{t-2} + g_4 v_{t-3} + g_5 v_{t-4} + g_6 v_{t-5} \qquad (2.18)$$

where

$$\beta_1 = 0$$

$$\beta_2 = \frac{a_4 - a_3}{\frac{1}{d}(1 - a_2 + a_{10})A_2 + (a_4 - a_3)}$$ [9]

$$\beta_3 = \frac{a_5 + a_4 - a_3}{\frac{1}{d}(1 - a_2 + a_{10} + a_{11})A_3 + (a_5 + a_4 - a_3)}$$

$$\beta_4 = \frac{a_6 + a_5 + a_4 - a_3}{\frac{1}{d}(1 - a_2 + a_{10} + a_{11} + a_{12})A_4 + (a_6 + a_5 + a_4 - a_3)}$$

$$\beta_5 = \frac{a_7+a_6+a_5+a_4-a_3}{\frac{1}{d}\,(1 - a_2+a_{10}+a_{11}+a_{12}+a_{13})A_5 + (a_7+a_6+a_5+a_4-a_3)}$$

$$\beta_6 = \frac{a_8+a_7+a_6+a_5+a_4-a_3}{\frac{1}{d}\,(1 - a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14})A_6 + (a_8+a_7+a_6+a_5+a_4-a_3)}$$

$$\beta_7 = \beta_8 = \ldots = 1$$

where

$$A_2 = c_6 + c_5 + c_4 + c_3 + c_2$$

$$A_3 = c_6 + c_5 + c_4 + c_3$$

$$A_4 = c_6 + c_5 + c_4$$

$$A_5 = c_6 + c_5$$

$$A_6 = c_6$$

$$\beta_8 = \beta_7 > \beta_6 > \beta_5 > \beta_4 > \beta_3 > \beta_2, \quad \beta_1 = 0;$$

$$\alpha_1 = \frac{a_1\beta_2 - a_3}{1 - a_2} \gtrless 0$$

$$\alpha_2 = \frac{1}{d}\,A_2\beta_2, \quad \alpha_3 = \frac{1}{d}\,A_3\beta_3, \quad \alpha_4 = \frac{1}{d}\,A_4\beta_4$$

$$\alpha_5 = \frac{1}{d} A_5\beta_5, \quad \alpha_6 = \frac{1}{d} A_6\beta_6, \quad \alpha_7 = \alpha_8 = \ldots = 0;$$

$$\gamma_1 = b_1\alpha_1, \quad \gamma_2 = \beta_2 + b_1\alpha_2, \quad \gamma_3 = \beta_3 + b_1\alpha_3$$

$$\gamma_4 = \beta_4 + b_1\alpha_4, \quad \gamma_5 = \beta_5 + b_1\alpha_5, \quad \gamma_6 = \beta_6 + b_1\alpha_6$$

$$\gamma_7 = \gamma_8 = \ldots = 1,$$

$$\gamma_7 > \gamma_6 > \gamma_5 > \gamma_4 > \gamma_3 > \gamma_2 > \gamma_1;$$

$$k_1 = 0, \quad k_2 = (1 - A_2)\beta_2, \quad k_3 = (1 - A_3)\beta_3$$

$$k_4 = (1 - A_4)\beta_4, \quad k_5 = (1 - A_5)\beta_5,$$

$$k_6 = (1 - A_6)\beta_6, \quad k_7 = k_8 = \ldots = 1$$

$$k_7 > k_6 > k_5 > k_4 > k_3 > k_2 > k_1;$$

$$y_0 = \bar{y}, \qquad p_0 = \frac{(1 - a_2 + a_{10})y_0 - a_0 + a_1 i^*}{(a_9 + a_8 + a_7 + a_6 + a_5 + a_4 - a_3)},$$

$$m_0 = p_0 + b_0 + b_1 y_0 - bi^*, \quad w_0 = p_0;$$

$$T_0 = -p_0(a_9 + a_8 + a_7 + a_6 + a_5 + a_4 - a_3) - a_{10}y_0;$$

$$g_1 = -a_3,$$

$$g_2 = (a_4 - a_3)(1 - \beta_2) - a_{10}\alpha_2$$

$$g_3 = (a_5 + a_4 - a_3)(1 - \beta_3) - (a_{10} + a_{11})\alpha_3$$

$$g_4 = (a_6 + a_5 + a_4 - a_3)(1 - \beta_4) - (a_{10} + a_{11} + a_{12})\alpha_4$$

$$g_5 = (a_7 + a_6 + a_5 + a_4 - a_3)(1 - \beta_5)$$

$$- (a_{10} + a_{11} + a_{12} + a_{13})\alpha_5$$

$$g_6 = (a_8 + a_7 + a_6 + a_5 + a_4 - a_3)(1 - \beta_6)$$

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$$- (a_{10} + a_{11} + a_{12} + a_{13} + a_{14})\alpha_6$$

$$g_7 = g_8 = \ldots = 0.$$

We now examine equations (2.13) - (2.18), the adjustment paths of the model's variables following an unanticipated devaluation of the home currency.

If we restrict the price to approach a new long-run equilibrium monotonically, we should have β_2 positive by assuming $a_4 > a_3$; i.e., the positive effect on the trade balance due to the transactions made by the traders who anticipated the devaluation at time t-1 outweighs the initial perverse effect. As shown in equations (2.14), (2.15) and (2.16), the system is neutral in the long run with respect to an unanticipated evaluation; that is, prices, the money supply and wages increase in the same proportion as the exchange rate. From equations (2.13) and (2.18), real output and the trade balance are unchanged after six periods, or in the long run. The interest rate always equals the foreign rate because only anticipated devaluations affect it. The economy attains a new long-run equilibrium exactly six periods after the devaluation.

The adjustment paths in the short and intermediate runs, however, depend on the structural parameters. Generally, short-run equilibrium depends on the values of fixed parameters, but intermediate-run paths depend on the adjustments of variable parameters. The model has three variable parameters: the renewal rate of labor contracts, the relative price and the income effects on the trade balance owing to trade contracts. In other words, the interplay of labor and trade contracts plays a decisive role in the intermediate run. A more detailed explanation follows.

The value of the A_i's represents the percentage of labor contracts not renewed at period i. When labor contracts are renewed to maintain the constancy of the real wage, a higher nominal wage will be set matching the higher price level resulting from a devaluation. For instance, the value of A_2 represents the sum of the percentages of firms operating in the 2nd, 3rd, 4th, 5th, 6th periods of their old labor contracts in the second period. Hence, in Figure 2.1, $A_2 = c_6 + c_5 + c_4 + c_3 + c_2$ in period t+1, and c_1 in period t+1 represents the percentage of the firms operating in the first period of new labor contracts. The darkened area in Figure 2.1 represents the accumulated percentage of the firms renewing labor contracts by period t+i and increases over time until period t+6. By period 6, the wage adjustment to an unanticipated devaluation is completed by all firms. On the other hand, the A_i's decrease over time. The monotonic decrease of the A_i's represents nominal wage increase as labor contracts are renewed gradually.

Because of the varying delivery lags of the trade contracts, the reaction of the trade balance to changes in relative prices and in income increases over time. For instance, the relative price effect increases from $a_5 + a_4 - a_3$ in period 3 to $a_6 + a_5 + a_4 - a_3$ in period 4, and the income effect increases from $a_{11} + a_{10}$ to $a_{12} + a_{11} + a_{10}$ during the same period. Both the sums of a_i's increase monotonically.

Using the feature of the three variable parameters, we discuss the price time path first. Since the values of the A_i's in the denominators of the β_i's decrease monotonically, the increasing renewal rates of labor

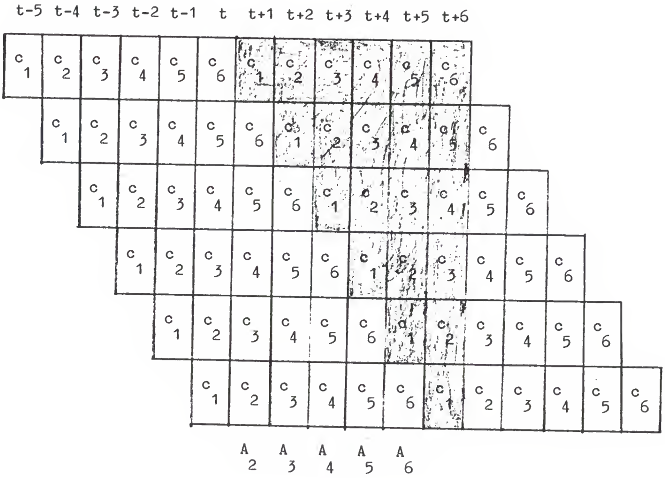
t-5 t-4 t-3 t-2 t-1 t t+1 t+2 t+3 t+4 t+5 t+6
c_1 c_2 c_3 c_4 c_5 c_6 c_1 c_2 c_3 c_4 c_5 c_6
c_1 c_2 c_3 c_4 c_5 c_6 c_1 c_2 c_3 c_4 c_5 c_6
c_1 c_2 c_3 c_4 c_5 c_6 c_1 c_2 c_3 c_4 c_5 c_6
c_1 c_2 c_3 c_4 c_5 c_6 c_1 c_2 c_3 c_4 c_5 c_6
c_1 c_2 c_3 c_4 c_5 c_6 c_1 c_2 c_3 c_4 c_5 c_6
c_1 c_2 c_3 c_4 c_5 c_6 c_1 c_2 c_3 c_4 c_5 c_6
A_2 A_3 A_4 A_5 A_6

Figure 2.1. Six-period overlapping labor contracts.

contracts raise the price gradually. In addition, the monotonic increase of the sum of the a_{3+i}'s in both the denominator and in the numerator of all β_i's implies the monotonic increase of the relative price effect on the trade balance lifts the price gradually. But the monotonic increase of the sum of the a_{9+i}'s implies the monotonic increase of the income effect on the trade balance dampens the price level. But over time, the positive effects on the price level from the gradual renewal of labor contracts and from relative price changes increasingly outweigh the negative effect from income changes. Because of the interplay of labor and trade contracts, the price level increases monotonically period by period to its long-run level.

For the output adjustment in the first period, since a devaluation works only through an increase in the value of imports in the first period, the trade balance decreases and this perverse effect depresses output. This negative effect on output of a devaluation is partially offset by a decrease in the real interest rate. The net effect on output is ambiguous. Output may decrease following a devaluation--a possibility pointed out by Krugman and Taylor (1978) and Cooper (1971). From the second period to the sixth period, the rate of change in output depends on the time path of the price level. If the price level increases gradually to its long-run level, output may grow increasingly and then decreasingly to the long-run level. But if the price level jumps in the second period, output may rise substantially in period one, then decrease gradually to the initial equilibrium level by the sixth period.

Under fixed exchange rates and perfect capital mobility, the money supply is fully endogenous. In each period, the rate of increase of the money stock just equals the inflation rate and the rate of increase of money demand due to the increase in output. In the first period, the inflation rate is zero; therefore, the increase of the money supply is the same as that of the increase in money demand caused by the increase of output. After six periods, the accumulated proportional change in the money supply equals that of the devaluation.

For the wage adjustment, the rate of wage increase equals the current inflation rate times the renewal percentages of labor contracts. Since labor contracts are supposedly distributed evenly, the wage will increase steadily to the long run level.

Before we discuss the adjustment process for the trade balance, let us compare the values of the coefficient g_i's with each other, then we can easily describe J-curve effects on the trade balance. If all denominators below are positive, the g's have the following relationships:

$$g_2 > g_1 \text{ if } a_4 > \frac{a_3^2 - a_3 A_2 a_{10} \frac{1}{d}}{\frac{1}{d}(1 - a_2)A_2 + a_3} \tag{2.19}$$

$$g_3 > g_2 \text{ if } a_5 > \frac{\frac{1}{d}\,[c_2(a_4 - a_3)^2 + a_{11}A_2A_3(a_4 - a_3)]}{\frac{1}{d^2}\,(1 - a_2 + a_{10})A_2A_3 - \frac{c_2}{d}(a_4 - a_3)} \tag{2.20}$$

$g_4 > g_3$ if

$$a_6 > \frac{\frac{1}{d}\,[c_3(a_5 + a_4 - a_3)^2 + a_{12}A_3A_4(a_5 + a_4 - a_3)]}{\frac{1}{d^2}\,(1 - a_2 + a_{10} + a_{11})A_3A_4 - \frac{c_3}{d}\,(a_5 + a_6 - a_3)} \tag{2.21}$$

$g_5 > g_4$ if

$$a_7 > \frac{\frac{1}{d}\,[c_4(a_6 + a_5 + a_4 - a_3)^2 + a_{13}A_4A_5(a_6 + a_5 + a_4 - a_3)]}{\frac{1}{d^2}(1 - a_2 + a_{10} + a_{11} + a_{12})A_4A_5 - \frac{c_4}{d}(a_6 + a_5 + a_4 - a_3)} \tag{2.22}$$

$g_6 > g_5$ if

$$a_8 > \frac{\frac{1}{d}[c_5(a_7+a_6+a_5+a_4-a_3)^2 + a_{14}A_5A_6(a_7+a_6+a_5+a_4-a_3)]}{\frac{1}{d^2}(1 - a_2+a_{10}+a_{11}+a_{12}+a_{13})A_5A_6 - \frac{c_5}{d}(a_7+a_6+a_5+a_4-a_3)} \tag{2.23}$$

If the denominators above are negative, then g_{i+1} is smaller than g_i. Since the denominators are more likely to be negative when more time has elapsed after a devaluation, the denominators are hardly ever positive for the fifth and sixth period after an unanticipated devaluation. This implies that the exchange rate effect on the trade balance will gradually decrease to zero and the effect on the trade balance of an unanticipated devaluation will be offset completely in the long run.

For the trade balance, a typical adjustment process is as follows. In the first period, there is a perverse effect. In the next two or three periods, since the nominal wage increases gradually but is still low and the supply and demand for imports and exports become more elastic, the trade balance improves gradually to the highest surplus level. During the last two or three periods, the effects from the wage increases outweigh those from the increases in relative price effects, and the trade balance gradually decreases to the initial level before the devaluation.

Using equations (2.19) to (2.23), we will identify some implausible and plausible time paths for the trade balance in the following four cases. Case A in Figure 2.2 and case B in Figure 2.3 are the implausible cases. Case C in Figure 2.4 is the most likely if a_4 exceeds a_3. In reality, however, case D in Figure 2.5 may be the most likely.

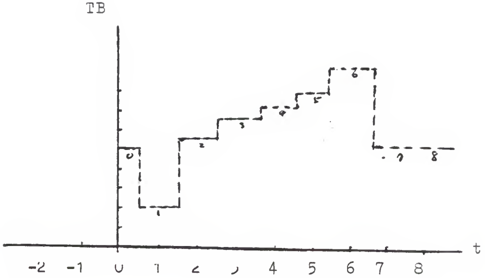

Figure 2.2. Case A: if $a_4 > a_3$ and conditions (2.19) - (2.23) hold.

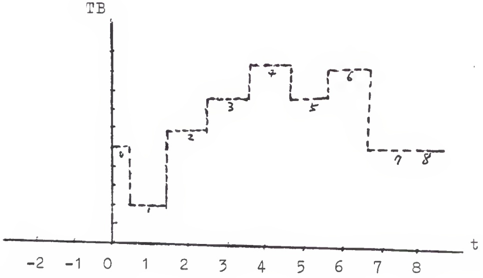

Figure 2.3. Case B: if $a_4 > a_3$ and conditions (2.19) - (2.21) and (2.23) hold, but (2.22) does not.

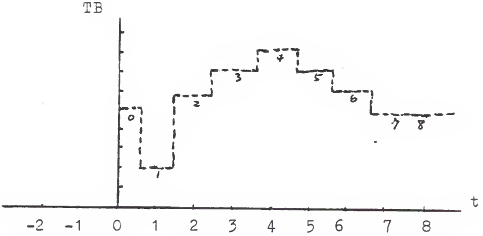

Figure 2.4. Case C: if $a_4 > a_3$ and conditions (2.19) - (2.21) hold, but (2.22) and (2.23) do not.

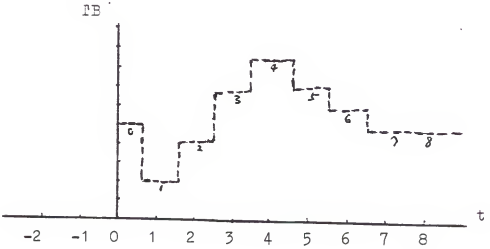

Figure 2.5. Case D: if $a_4 < a_3$, $a_5 + a_4 > a_3$ and conditions (2.20) and (2.21) hold, but (2.22) and (2.23) do not.

The implausibility of case A and case B follows from the implausibility of (2.22) and (2.23). As we mentioned before, (2.22) and (2.23) are likely to fail since the negative effects from the wage increase outweigh the positive effects from the increase in the reactions for tradeables.

In the above analysis, the price level is assumed to move up monotonically to approach the long-run equilibrium. But if the anticipated relative price effect on the trade balance at period t-1 is too small to offset the initial perverse effect, or the improvements in the trade balance from the traders with an expectation at time t-1 are not enough to outweigh the initial perverse effect, a_3 will exceed a_4. If this happens, the price will go down in period 2 because $(1 - a_2 + a_{10})\frac{A_2}{d} + (a_4 - a_3) > 0$ is assumed to ensure a unique solution for β_2.[11]

$$\text{If } \beta_2 < 0, \text{ then } \alpha_1 < 0,\ \alpha_2 < 0,\ \gamma_2 < 0,\ \gamma_1 < 0,\ g_2 < 0. \tag{2.24}$$

Condition (2.24) implies that if $a_3 > a_4$, an anticipated devaluation can lead to a reduction in output and the money supply and can generate a perverse effect on the trade balance. For the traders who form expectations at period t-2, t-3, t-4, t-5 and t-6, v_{t-1} is an unanticipated shock, but for the traders forming expectations at period t-1, v_{t-1} is an anticipated shock. Therefore, an anticipated shock could prolong the J-curve effect. This finding is contrary to the general result of the devaluation literature under rational expectations that only an unanticipated shock could affect the J curve.

2.4 Three Special Cases

2.4.1 Case One

We now proceed to compare the general solution above with solutions from three special cases. In case one, all traders form their expectations at period t-1, i.e., $\bar{a}_4 = a_4+a_5+a_6+a_7+a_8+a_9$, $\bar{a}_{10} = a_{10}+a_{11}+a_{12}+a_{13}+a_{14}+a_{15}$. But labor contracts are the same as those in the general model. Therefore, case one incorporates short-term trade contracts with long-term labor contracts.

The solution for case one is the following:

$$\beta_1 = 0$$

$$\beta_2 = \frac{\bar{a}_4 - a_3}{\frac{1}{d}(1 - a_2 + \bar{a}_{10})A_2 + (\bar{a}_4 - a_3)}$$

$$\beta_3 = \frac{\bar{a}_4 - a_3}{\frac{1}{d}(1 - a_2 + \bar{a}_{10})A_3 + (\bar{a}_4 - a_3)}$$

$$\beta_4 = \frac{\bar{a}_4 - a_3}{\frac{1}{d}(1 - a_2 + \bar{a}_{10})A_4 + (\bar{a}_4 - a_3)}$$

$$\beta_5 = \frac{\bar{a}_4 - a_3}{\frac{1}{d}(1 - a_2 + \bar{a}_{10})A_5 + (\bar{a}_4 - a_3)}$$

$$\beta_6 = \frac{\bar{a}_4 - a_3}{\frac{1}{d}(1 - a_2 + \bar{a}_{10})A_6 + (\bar{a}_4 - a_3)}$$

$$\beta_7 = \beta_8 = \dots = 1,$$

$$\beta_7 > \beta_6 > \beta_5 > \beta_4 > \beta_3 > \beta_2; \quad \beta_1 = 0;$$

$$\alpha_1 = \frac{a_1\beta_2 - a_3}{1 - a_2} \overset{>}{(<)} 0, \quad \alpha_2 = \frac{1}{d} A_2\beta_2$$

$$\alpha_3 = \frac{1}{d} A_3\beta_3, \quad \alpha_4 = \frac{1}{d} A_4\beta_4, \quad \alpha_5 = \frac{1}{d} A_5\beta_5,$$

$$\alpha_6 = \frac{1}{d} A_6\beta_6, \quad \alpha_7 = \alpha_8 = \dots = 0;$$

$$\gamma_1 = b_1\alpha_1, \quad \gamma_2 = \beta_2 + b_1\alpha_2, \quad \gamma_3 = \beta_3 + b_1\alpha_3,$$

$$\gamma_4 = \beta_4 + b_1\alpha_4, \quad \gamma_5 = \beta_5 + b_1\alpha_5, \quad \gamma_6 = \beta_6 + b_1\alpha_6,$$

$$\gamma_7 = \gamma_8 = \dots = 1;$$

$$\gamma_7 > \gamma_6 > \gamma_5 > \gamma_4 > \gamma_3 > \gamma_2 > \gamma_1;$$

$$k_1 = 0, \quad k_2 = (1 - A_2)\beta_2, \quad k_3 = (1 - A_3)\beta_3,$$

$$k_4 = (1 - A_4)\beta_4, \quad k_5 = (1 - A_5)\beta_5$$

$$k_6 = (1 - A_6)\beta_6, \quad k_7 = k_8 = \dots = 1;$$

$$k_7 > k_6 > k_5 > k_4 > k_3 > k_2 > k_1;$$

$$g_1 = -a_3$$

$$g_2 = (\bar{a}_4 - a_3)(1 - \beta_2) - \bar{a}_{10}\alpha_2,$$

$$g_3 = (\bar{a}_4 - a_3)(1 - \beta_3) - \bar{a}_{10}\alpha_3,$$

$$g_4 = (\bar{a}_4 - a_3)(1 - \beta_4) - \bar{a}_{10}\alpha_4,$$

$$g_5 = (\bar{a}_4 - a_3)(1 - \beta_5) - \bar{a}_{10}\alpha_5,$$

$$g_6 = (\bar{a}_4 - a_3)(1 - \beta_6) - \bar{a}_{10}\alpha_6,$$

$$g_7 = g_8 = \dots = 0$$

$g_2 > g_3 > g_4 > g_5 > g_6 > g_7$[12]; (2.25)

$$y_0 = \bar{y}, \quad p_0 = \frac{(1 - a_2 + \bar{a}_{10})y_0 - a_0 + a_1 i^*}{(\bar{a}_4 - a_3)}$$

$$m_0 = p_0 + b_0 + b_1 y_0 - b_2 i^*, \quad w_0 = p_0,$$

$$T_0 = - p_0(\bar{a}_4 - a_3) - a_{10} y_0;$$

In the long run, this special case produces the same results as the general case. The system is also neutral with respect to an unanticipated devaluation. The price level, the money supply and the wage all increase in the same proportion as the exchange rate. Output and the trade balance are unchanged. The interest rate always equals the foreign rate. The whole economy attains a new long-run equilibrium exactly six periods after the devaluation.

In the short and intermediate runs, however, the adjustment processes for this case differ from those for the general case. Since all agents are assumed to form their expectations at period t-1, the trade balance equation used in case one is equation (2.2). The value of $\bar{a}_4$ of equation (2.2) is much larger than a_4 of equation (2.3). The value of $\bar{a}_4$ is fixed over time, that is, the relative price effect on the trade balance is constant over time or exports and imports react instantaneously to changes in the exchange rate. Due to the large and fixed value of $\bar{a}_4$, the values of parameters β_2, α_2, γ_2, k_2 and g_2 are much higher than those in the general case, but the differences between them become smaller and smaller and approach zero in period 6.

The price level is unchanged in the first period, but jumps to a high level in period 2, then increases monotonically to the long-run level. The jump is due to the huge value of $\bar{a}_4$ caused by the special specification of trade contracts, and the monotonic increases are due to the gradual renewals of labor contracts.

Output in the first period may jump up substantially because the expected real interest rate effect outweighs the initial perverse effect, a result of the expected price jump in period 2. After period 1, output may decrease monotonically to the initial level. Therefore, an unanticipated devaluation is not likely to have contractionary effects on output in case one.

The adjustment processes for the money supply and wages are almost the same as those of the general case except that the money supply may not decrease in period 1.

Finally, let us turn to the adjustment paths for the trade balance. After the initial perverse effects, the large value of g_2, caused by $\bar{a}_4$, turns the trade balance into the highest surplus in period 2 after an unanticipated devaluation and the trade balance decreases monotonically thereafter to the initial level. Hence, it is impossible for an anticipated devaluation to prolong the J-curve effects for case one. This is why the recent devaluation literature under rational expectations suggests that only an unanticipated devaluation can generate J-curve effects. The shape of an J-curve in case one is illustrated in Figure 2.6.

To reiterate, the shortcomings of case one are due to the special specification of trade contracts with only a one-period lag. Only one type of J-curve can be generated from case one. Therefore, case one is too special to explain the general shapes of J-curves observed for many countries.

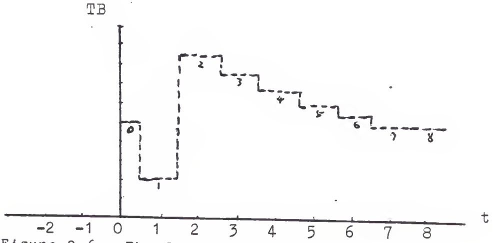

Figure 2.6. The J-curve shape for case one.

2.4.2 Case Two

Next, we discuss another special case which also uses equation (2.2) as the trade balance equation. All trade contracts are assumed to have only a one-period lag, that is, all traders form expectations at period t-1. All labor contracts are supposed to run for two periods, that is, $c_3 = c_4 = c_5 = c_6 = 0$, $c_1 + c_2 = 1$. The general solutions in section 2.3 will be reduced to the following:

$$\beta_1 = 0$$

$$\beta_2 = \frac{\bar{a}_4 - a_3}{\frac{1}{d}(1 - a_2 + \bar{a}_{10})c_2 + (\bar{a}_4 - a_3)},$$

$$\beta_3 = \beta_4 = \dots = 1;$$

$$\alpha_1 = \frac{a_1\beta_2 - a_3}{1 - a_2} \overset{>}{(<)} 0, \qquad \alpha_2 = \frac{1}{d} c_2\beta_2$$

$$\alpha_3 = \alpha_4 = \dots = 0;$$

$$\gamma_1 = b_1\alpha_1, \quad \gamma_2 = \beta_2 + b_1\alpha_2,$$

$$\gamma_3 = \gamma_4 = \gamma_5 = \dots = 1;$$

$$k_1 = 0, \quad k_2 = c_1\beta_2,$$

$$k_3 = k_4 = \ldots = 1;$$

$$g_1 = -a_3,$$

$$g_2 = (\bar{a}_4 - a_3)(1 - \beta_2) - a_{10}\alpha_2,$$

$$g_3 = g_4 = g_5 = \ldots = 0;$$

$$y_0 = c_0, \quad w_0 = p_0, \quad p_0 = \frac{(1 - a_2 + \bar{a}_{10})y_0 - a_0 + a_1 i^*}{(\bar{a}_4 - a_3)},$$

$$m_0 = p_0 + b_0 + b_1 y_0 - b_2 i^*, \quad T_0 = - p_0(\bar{a}_4 - a_3) - \bar{a}_{10} y_0;$$

An examination of the solutions for case two yields the following results. In the long run, case two is identical to the general case and case one. That is, the system is neutral with respect to an unanticipated devaluation. In a word, the trade balance and output and interest rate are unchanged, and the price level, money supply and wage increase in the same proportion as the exchange rate. The economy completes the entire adjustment process in two periods after the devaluation.

In this case, a one-period intermediate run is too short to describe properly the entire adjustment process. In the short run, the adjustment processes are the same as in case one, but the pace of adjustment is faster. The value of $\bar{a}_4$ is the same in cases one and two, but the values of c_1 and c_2 in case two are much higher than in case one. Since c_3, c_4, c_5 and c_6 are set to zero and $c_1 + c_2 = 1$, the values of c_1 and c_2 for case two could be three times those in case one and in the general case. The large values of c_1 and c_2 allow the wage to increase faster than in case one because more labor contracts will be renewed in period 2. Due to the large values of $\bar{a}_4$, c_1 and c_2 resulting from the short trade and labor contracts, prices, the money supply and wages are higher than those in case one and much higher than those in the general case. Output and the trade balance in period 2 are smaller than those in case one, but still higher than those in the general case.

In the first period after the devaluation, prices and wages are unchanged. Output generally will increase since the large expected real interest rate effects could outweigh the initial perverse effects. The money supply increases quickly, and the trade balance deteriorates.

In the second period, prices and wages jump to very high levels, but the price jump is not as high as the increase in the money supply. Output is still higher than the long-run level. The trade balance rises instantaneously to the highest surplus. As in case one, it is impossible for an anticipated devaluation to prolong

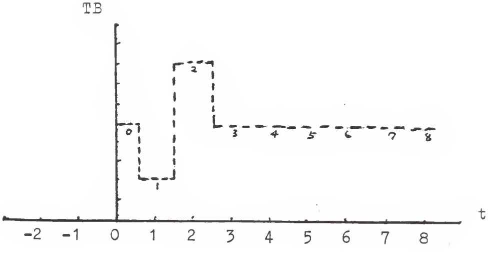

Figure 2.7. The J-curve shape for case two.

the J-curve effects. The J-curve in case two is illustrated in Figure 2.7.

Finally, let us point out the defects of case two. Case two shares the same problems as case one of the fixed relative price effect on the trade balance due to short-term trade contracts. In addition, as a result of short-term labor contracts, case two overlooks the intermediate run. The problems with both cases have permeated the devaluation literature. By incorporating long-term trade and labor contracts, the general case removes these shortcomings.

2.4.3 Case Three

For some countries, labor contracts may last 2 or 3 years while trade contracts generally last 1 year at most. Accordingly, in case three all labor contracts are assumed to run for six periods evenly while trade contracts last two periods at most. That is, some trade contracts have a one-period delivery lag and the others have a lag of two periods. This implies that $a_6 = a_7 = a_8 = a_9 = 0$, $a_{12} = a_{13} = a_{14} = a_{15} = 0$. Therefore, the general solution in section 2.3 reduces to the following:

$$\beta_1 = 0$$

$$\beta_2 = \frac{a_4 - a_3}{\frac{1}{d}(1 - a_2 + a_{10})A_2 + (a_4 - a_3)}$$

$$\beta_3 = \frac{a_5 + a_4 - a_3}{\frac{1}{d}(1 - a_2 + a_{10} + a_{11})A_3 + (a_5 + a_4 - a_3)}$$

$$\beta_4 = \frac{a_5 + a_4 - a_3}{\frac{1}{d}(1 - a_2 + a_{10} + a_{11})A_4 + (a_5 + a_4 - a_3)}$$

$$\beta_5 = \frac{a_5 + a_4 - a_3}{\frac{1}{d}(1 - a_2 + a_{10} + a_{11})A_5 + (a_5 + a_4 - a_3)}$$

$$\beta_7 = \beta_8 = \ldots = 1;$$

$$\alpha_1 = \frac{a_1\beta_2 - a_3}{1 - a_2} \gtrless 0 \qquad \alpha_2 = \frac{1}{d} A_2\beta_2$$

$$\alpha_3 = \frac{1}{d} A_3\beta_3 \qquad \alpha_4 = \frac{1}{d} A_4\beta_4 \qquad \alpha_5 = \frac{1}{d} A_5\beta_5$$

$$\alpha_6 = \frac{1}{d} A_6\beta_6, \qquad \alpha_7 = \alpha_8 = \ldots = 0;$$

$$\gamma_1 = b_1\alpha_1 \qquad \gamma_2 = \beta_2 + b_1\alpha_2 \qquad \gamma_3 = \beta_3 + b_1\alpha_3$$

$$\gamma_4 = \beta_4 + b_1\alpha_4 \qquad \gamma_5 = \beta_5 + b_1\alpha_5 \qquad \gamma_6 = \beta_6 + b_1\alpha_6$$

$$\gamma_7 = \gamma_8 = \ldots = 1;$$

$$\gamma_7 > \gamma_6 > \gamma_5 > \gamma_4 > \gamma_3 > \gamma_2 > \gamma_1;$$

$$k_1 = 0, \qquad k_2 = (1 - A_2)\beta_2, \qquad k_3 = (1 - A_3)\beta_3$$

$$k_4 = (1 - A_4)\beta_4, \qquad k_5 = (1 - A_5)\beta_5, \qquad k_6 = (1 - A_6)\beta_6$$

$$k_7 = k_8 = \ldots = 1;$$

$$k_7 > k_6 > k_5 > k_4 > k_3 > k_2 > k_1;$$

$$g_1 = -a_3$$

$$g_2 = (a_4 - a_3)(1 - \beta_2) - a_{10}\alpha_2$$

$$g_3 = (a_5 + a_4 - a_3)(1 - \beta_3) - (a_{10} + a_{11})\alpha_3$$

$$g_4 = (a_5 + a_4 - a_3)(1 - \beta_4) - (a_{10} + a_{11})\alpha_4$$

$$g_5 = (a_5 + a_4 - a_3)(1 - \beta_5) - (a_{10} + a_{11})\alpha_5$$

$$g_6 = (a_5 + a_4 - a_3)(1 - \beta_6) - (a_{10} + a_{11})\alpha_6$$

$$g_7 = g_8 = \dots = 0$$

$$y_0 = \bar{y}, \qquad p_0 = \frac{(1 - a_2 + a_{10})\bar{y} - a_0 + a_1 i^*}{(a_5 + a_4 - a_3)}$$

$$m_0 = p_0 + b_1 + b_1 y_0 - bi^*, \qquad w_0 = p_0;$$

$$T_0 = - p_0(a_5 + a_4 - a_3) - a_{10}y_0.$$

In the long run, case three produces the same results as the general case. We will not repeat them here. In the short and intermediate run, case three generally generates the adjustment paths close to those generated by the general case in section 2.3. Therefore, we will not reiterate them either.

Two features distinguish case three. The first is that the pace of adjustment for the entire economy during the first three periods is generally faster than that of the general case, but it is slower after period 3. This is due to the specification of trade contracts in case

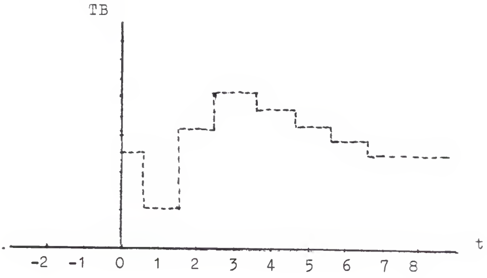

Figure 2.8. A J-curve shape for case three.

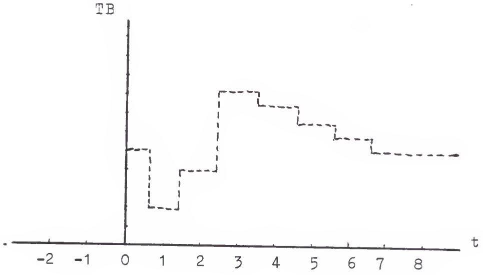

Figure 2.9. A J-curve shape for case three.

three. Under the specification, the reaction of the trade balance to changes in relative prices and income is faster than those in the general case.

The second feature is that the trade balance reaches its highest position in period 3 for case three while in the general case the trade balance peaks in period 4. Two plausible time paths for the trade balance are in Figure 2.8 and 2.9. The J-curve in Figure 2.8 is the most likely for case 3 if a_4 exceeds a_3. But if a_3 exceeds a_4, the path in Figure 2.9 may be the most likely one. Actually, the J-curves in Figures 2.8 and 2.9 are like those in Figures 2.4 and 2.5. Accordingly, the time paths for the trade balance generated by case three may be also most likely.

2.5 Numerical Simulations

It seems worthwhile to provide some numerical examples to demonstrate that the incorporation of overlapping trade contracts and labor contracts into the open macroeconomic model is in fact important.

The assumed values of parameters are given at the top of each table. Although the values chosen are arbitrary, the time paths generated are within a reasonable range.

In all tables, period 1 describes the short run, periods 2-6 depict the intermediate run and period 7 delineates the long run. In the long run, all β, γ and k are equal to one; that is, the price level, money supply and wage change in the same proportion as the change in the exchange rate. Zero for g and α represent that, after six periods, the trade balance and output return to their initial levels.

Let us turn to the short run and the intermediate run. Table 2.3 is used to describe the general case C. In period one, prices and the wage are unchanged, and the trade balance deteriorates immediately because of J-curve effects. The real interest rate decreases through the expected price inflation for period 2. The reduction in the real interest rate dominates the J-curve effects, raises the excess aggregate demand for output and output increases. The increase in output raises the demand for money. Since the money supply is fully endogenous under fixed exchange rates, an increase in money demand is met with an equal increase in money supply. In the second period, the real price effect on the trade balance outweighs the J-curve effects. The trade balance improves, the money supply and the price level increase, and output falls but is still above the initial level. The wage increases by one-sixth of the price inflation rate because one-sixth of the labor contracts have been renewed and set the nominal wage higher to maintain the constancy of the real wage. In period 3, as traders with

Table 2.3. General case C.

Assumed values of parameters	$a_1=120$, $a_2=0.7$, $a_3=15$, $a_4=20$, $a_5=15$, $a_6=10$, $a_7=5$, $a_8=5$, $a_9=0$, $a_{10}=0.08$, $a_{11}=0.07$, $a_{12}=0.06$, $a_{13}=0.05$, $a_{14}=0.04$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_i = 1/6$, $i=1,\ldots,6$.					
Period	1	2	3	4	5	6	7
β	0	0.13	0.40	0.54	0.65	0.8	1
α	2	10.8	27	27	21.5	13.3	0
γ	0.02	0.24	0.67	0.81	0.87	0.93	1
k	0	0.02	0.13	0.27	0.44	0.66	1
g	-15	3.5	7.95	8.13	6.06	4	0

Table 2.4. General case D.

Assumed values of parameters	$a_1=60$, $a_2=0.7$, $a_3=15$, $a_4=10$, $a_5=20$, $a_6=15$, $a_7=5$, $a_8=5$, $a_9=0$, $a_{10}=0.08$, $a_{11}=0.07$, $a_{12}=0.06$, $a_{13}=0.05$, $a_{14}=0.04$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_i = 1/6$, $i=1,\ldots,6$.					
Period	1	2	3	4	5	6	7
β	0	-0.18	0.33	0.54	0.65	0.8	1
α	-86	-15	22	27	21.5	13.3	0
γ	-0.86	-0.33	0.55	0.81	0.87	0.93	1
k	0	-0.03	0.11	0.27	0.44	0.66	1
g	-15	-4.7	6.75	8.13	6.6	4	0

Table 2.5. Case one.

Assumed values of parameters	$a_1=60$, $a_2=0.7$, $a_3=15$, $\bar{a}_4=55$, $a_5=0$, $a_6=0$, $a_7=0$, $a_8=0$, $a_9=0$, $\bar{a}_{10}=0.3$, $a_{11}=0$, $a_{12}=0$, $a_{13}=0$, $a_{14}=0$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_i = 1/6$, $i=1,\ldots,6$.					
Period	1	2	3	4	5	6	7
β	0	0.44	0.50	0.57	0.67	0.80	1
α	38	37	33	29	22	13	0
γ	0.38	0.80	0.83	0.85	0.89	0.93	1
k	0	0.07	0.16	0.29	0.45	0.66	1
g	-15	11.4	10	8.65	8.11	4	0

Table 2.6. Case two.

Assumed values of parameters	$a_1=60$, $a_2=0.7$, $a_3=15$, $\bar{a}_4=55$, $a_5=0$, $a_6=0$, $a_7=0$, $a_8=0$, $a_9=0$, $\bar{a}_{10}=0.3$, $a_{11}=0$, $a_{12}=0$, $a_{13}=0$, $a_{14}=0$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_1 = c_2 = 1/2$, $c_3 = c_4 = c_5 = c_6 = 0$.						
Period	1	2	3	4	5	6	7
β	0	0.57	1	1	1	1	1
α	64	29	0	0	0	0	0
γ	0.64	0.86	1	1	1	1	1
k	0	0.29	1	1	1	1	1
g	-15	8.5	0	0	0	0	0

Table 2.7. Case three.

Assumed values of parameters	$a_1=60$, $a_2=0.7$, $a_3=15$, $a_4=25$, $a_5=30$, $a_6=0$, $a_7=0$, $a_8=0$, $a_9=0$, $a_{10}=0.15$, $a_{11}=0.15$, $a_{12}=0$, $a_{13}=0$, $a_{14}=0$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_i = 1/6$, $i=1,...,6$.						
Period	1	2	3	4	5	6	7
β	0	0.21	0.50	0.57	0.67	0.84	1
α	8	17.4	33.5	28.5	22.1	13.3	0
γ	0.08	0.38	0.83	0.85	0.89	0.93	1
k	0	0.04	0.17	0.29	0.45	0.66	1
g	-15	5.29	9.95	8.65	6.57	4.01	0

prior expectations at period t-1 and t-2 can adjust their exports and imports, the relative price effect increases to $a_4 + a_5 - a_3$. An additional one-sixth of the labor contracts have been renewed, the wage increased to one-third of the price increase. Since the positive effects from the trade contracts still outweigh the offsetting effects from the labor contracts, the trade balance and output keep improving. The same adjustment processes continue in period 4. But in periods 5 and 6, owing to the renewal of additional labor contracts, the negative effects from labor contracts dominate the positive effects from trade contracts. Hence, the trade balance and output begin declining gradually to the long-run level.

For the rest of the tables, we shall not reiterate those adjustment processes which are similar to those in Table 2.3 but describe their distinctive characteristics.

The special features of Table 2.4 result from the assumption that a_3 exceeds a_4. In period 1, output contracts because of J-curve effects and an increase in the real interest rate due to the expected reduction in price of period 2. The money supply falls. In period 2, since J-curve effects still dominate the positive relative price effects, prices, the money supply and wages decrease, while output and the trade balance improve but are still below the initial levels. Since the relative price elasticity of the trade balance is small in the short run, Table 2.4 describes the most likely case for most countries under fixed exchange rates.

Table 2.5 is for special case one in which all agents are assumed to form prior expectations of relative prices at period t-1. Therefore, $\bar{a}_4$ is equal to the sum of a_4, a_5, a_6, a_7, a_8 and a_9 in Table 2.3 and is much higher than the value of a_4. Owing to a large $\bar{a}_4$, the price level could jump very high from period 1 to period 2. A big reduction in the real interest rate due to the price jump expected for period 2 will immediately raise the aggregate demand for output to a very high position, and output expands very quickly. Therefore, the value of α_1 here generally is much higher than that of the general case and it seems unlikely for a devaluation to have a contractionary effect on output. After perverse effects, the trade balance swings to the highest surplus in period 2, then decreases montonously to the initial level.

Table 2.6 illustrates the special case two. As in case one, due to the large value of $\bar{a}_4$, the price level for period 2 and output for period 1 jump very high. Because of the shortness of two-period labor contracts, the intermediate run is too short. From Table 2.6, we find one of the shortcomings of the special case two is that the trade balance drops to the initial level instantaneously from its previous highest surplus.

To reiterate, both special cases one and two cannot explain the general J-curve phenomenon, and the price jump in period 2 seems too high to be true in the real world under fixed exchange rates.

Table 2.7 is used to illustrate special case three. As predicted in section 2.43, the adjustment pace for entire economy is a little faster for the first three periods but a little slower for the next three periods than those in Table 2.3. The trade balance becomes highest in period 3 because a_4 exceeds a_3. Generally, the adjustment process is close to that in Table 2.3.

2.6 Conclusions

The model incorporating the overlapping trade contracts and labor contracts in this chapter generates a rich variety of gradual adjustment processes. This provides a strong contrast to the stark simplicity of the instantaneous adjustment in the models in which the trade balance is assumed to be like equations (2.1) and (2.2). The most serious deficiency of the equations is the assumption that export and import values react relatively fast, instantaneously in some cases, to changes in relative prices. However, in reality, this reaction is distributed over time. It is quite likely that the short-run reaction is very slow because traders are not able to react to an unanticipated devaluation very quickly. In the intermediate run, the adjustment processes may be significantly influenced by the consecutive and gradual renewals of labor contracts and the trade contracts with different delivery lags. The long-run reaction is zero because, in the long run, the entire economy is neutral.

The first two special cases may be justified from the viewpoint of the long run and the short run, but they fail to account for the intermediate run. Case D illustrated on page 36 may be most likely, and a small relative price effect on the trade balance in initial periods may prolong the J-curve effects on the trade balance. An unexpected devaluation has a contemporaneously contractionary effect on output if the J-curve effect dominates the expected real interest rate effect in the short run.

Notes

[1] The Marshall-Lerner condition states that a devaluation improves the trade balance if and only if the sum of the domestic and foreign elasticities of demands for imports exceeds unity under the assumption that the elasticities of supplies of exportables and importables are infinite and that the trade account is initially balanced.

[2] The literature on the J-curve includes several other papers. Levin (1983, 1985) used Williamson's equation (2.1), while Ueda (1983) followed Driskill's equation (2.2). Currie (1985) replaced the term for the expected relative price in equation (2.2) by a distributed lag of the relative price, but kept the current relative price term of equation (2.2). All of them share the same problem of constant price elasticity of the trade balance over time.

[3] In addition, we could find the following phenomenon from Tables D-1, D-2 and D-3. In the short run and long run, the effects of a devaluation were the same in nature for U.K., Korea and Nepal, that is, a perverse effect in the short run and neutrality in the long run. But the length of the intermediate run is different, very short for Nepal and long for the U.K. and Korea.

[4] For references, see Table 2.1, which is from Magee (1974, p. 132).

[5] A detailed explanation of the entry lag was given by Magee (1974, p. 131). The entry lag may comprise at least three elements: unloading the ship, the ten-day grace period for filing the entry form for goods entered under immediate delivery, and the transshipment time between the port of importation and the port at which the goods are entered. For example, goods that come through Houston for an importer in Toledo, Ohio, may be transshipped to the Toledo port of entry for his convénience in paying the estimated duties and bond.

[6] Grassman (1973) found that roughly two-thirds of contracts were in the seller's currency and one-fourth in purchaser's.

[7] Because we assume that all contracts are written in terms of the producer's currency, the value of the trade balance equals $P_xX - eP_mM$. Devaluing the domestic currency implies an increase in e, and hence an increase in the value of imports. As a result, the trade balance deteriorates if X and M remain unchanged.

[8] More importantly, it makes the intermediate-run analysis possible.

[9] Generally, the rational expectational equations have an infinite number of solutions. If the number of characteristic roots which exceed unity equals the order of the rational expectations model, we can get a unique solution for the free parameters. The denominators of all β_i's should be positive because the characteristic root is assumed greater than unity in order to get a unique solution for the β_i's.

[10] If J-curve effects are dominated, the value of g_i's is positive. For instance,

$$g_6 = \frac{(a_8+a_7+a_6+a_5+a_4-a_3)-\frac{A_6}{d}(1-a_2)}{\frac{1}{d}(1-a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14})+(a_8+a_7+a_6+a_5+a_4-a_3)}$$

Since both denominator and numerator are positive, g_6 is positive.

[11] See note 9.

[12] It is easy to prove the relationship shown in equation (2.25). For instance,

$$g_2 - g_3 = \frac{(\bar{a}_4-a_3)^2(1-a_2)}{[(1-a_2+\bar{a}_{10})A_2+(\bar{a}_4-a_3)][(1-a_2+\bar{a}_{10})A_3+(\bar{a}_4-a_3)]} > 0$$

Similarly, we can get $g_3 > g_4$, etc.

CHAPTER 3
UNANTICIPATED MONETARY DISTURBANCES AND EXCHANGE RATE DYNAMICS UNDER FLEXIBLE EXCHANGE RATES

3.1 Introduction

Using a rational expectations model incorporating trade and labor contracts, this chapter investigates exchange rate dynamics after an unanticipated increase in the money supply.

Recently, Dornbusch (1976) developed a theory of exchange rates under perfect capital mobility. He assumed that goods markets adjust more slowly than asset markets and expectations are rational. The difference in the speeds of adjustment gives rise to a phenomenon known as overshooting of the exchange rate. Niehans (1977), in contrast, emphasized the dynamic interaction between the classical stock aspects of adjustment, stressed by the monetary theory, and the flow aspects of adjustment, stressed by the elasticity approach. It was shown that, even in a very simple model of lagged asset adjustment and imperfect capital substitutability, the interaction between trade and capital flows could produce a large variety of adjustment paths, undershooting and overshooting, monotonic and cyclical. Under the assumption of imperfect capital mobility and substitutability, Driskill (1981a) incorporated J-curve effects into a rational expectations model to permit trade flows to create nonmonotonic exchange rate adjustments toward long-run equilibrium. The adjustment may lead to a contemporaneous undershooting or overshooting.

In this chapter, we keep the assumption of perfect capital mobility and substitutability in the Dornbusch model (1976), but incorporate the J-curve effects and long-term trade and labor contracts into a rational expectations model. Surprisingly, we prove that a significant J-curve effect would stabilize, not destabilize, the contemporaneous exchange rate movement after an unanticipated increase in the money supply. Furthermore, the stabilizing J-curve effects would generate, surprisingly, contemporaneous countershooting of the exchange rate, that is, a contemporaneous appreciation after an unanticipated increase in the money supply. An explanation of the phenomenon is that a significant J-curve effect brings about expectations that an undershooting or overshooting would happen in the next period. Accordingly, the current real interest rate increases rather than decreases and the exchange rate appreciates contemporaneously, a phenomenon which we call countershooting. The most likely time path of the exchange rate generated by this model is the following: countershooting in the short run, undershooting in the second period, overshooting in the next couple of periods, then undershooting in the last couple of periods.

These results are not absurd or impossible. If we drop the J-curve effects and the long-term trade and labor contracts from the model in this chapter, the results are completely consistent with those from the Dornbusch model (1976). The Dornbusch model has received some support from empirical studies, such as Frenkel (1976) and Bilson (1978).[1] But in those cases, the J-curve effects may be insignificant. If they were significant, the results might be close to the ones presented in this chapter.

In the next section, the model is set up. Section 3.3 presents the solution of the model. Section 3.4 discusses exchange rate dynamics. Section 3.5 presents adjustment processes of output, wages and the interest rate.

3.2 The Model

The model is described by the following six equations:

$$y_t = a_0 - a_1(i_t - {}_tp_{t+1} + p_t) + a_2y_t - a_3(e_t - p_t)$$

$$+ \sum_{i=1}^{6} a_{3+i}({}_{t-i}e_t - {}_{t-i}p_t) - \sum_{i=1}^{6} a_{9+i}\ {}_{t-i}y_t \qquad (3.1)$$

$$m_t - p_t = b_0 + b_1 y_t - b_2 i_t \tag{3.2}$$

$$i_t = i^* + {}_t e_{t+1} - e_t \tag{3.3}$$

$$m_t = \sum_{i=0}^{\infty} u_{t-i} \tag{3.4}$$

$$p_t = {}_{t-1}w_t + d({}_{t-1}y_t - \bar{y}) \tag{3.5}$$

$$w_t = \sum_{i=1}^{6} c_i \, {}_{t-i}p_t, \quad \sum_{i=1}^{6} c_i = 1, \quad c_i > 0 \tag{3.6}$$

Equation (1) describes the domestic economy's IS curve in which the trade balance incorporates the concept of the overlapping trade contracts. Equation (3.2) and (3.3) depict the asset markets. Equation (3.5) delineates the supply side of the economy with a simple price equation which reflects long-term Fischer-type contracts. Since equations (3.1), (3.2), (3.3), (3.5) and (3.6) are the same as those in the model under fixed exchange rates, we will not discuss them further here.

The only difference lies in equation (3.4). Under fixed exchange rates, the exchange rate is exogenous and the supply of money is endogenous. But under flexible exchange rates, the supply of money is exogenous and the exchange rate endogenous. Therefore equation (2.9) for the model under fixed exchange rates should be replaced by equation (3.4) above. Equation (3.4) says that the money supply is subject to random shocks. The random term u's are white noise processes with variance σ_u^2.

3.3 The Solution of the Model

Using Muth's (1961) method of undetermined coefficients in the time domain using moving averages, we get the solution for the model. The solutions for the time paths of output, the price level, the exchange rate, the nominal wage, the interest rate and the trade balance are as follows:

$$y_t = y_0 + \alpha_1 u_t + \alpha_2 u_{t-1} + \alpha_3 u_{t-2} + \alpha_4 u_{t-3} + \alpha_5 u_{t-4} + \alpha_6 u_{t-5} \tag{3.7}$$

$$p_t = p_0 + \beta_2 u_{t-1} + \beta_3 u_{t-2} + \beta_4 u_{t-3} + \beta_5 u_{t-4} + \beta_6 u_{t-5} + \sum_{i=6}^{\infty} u_{t-i} \tag{3.8}$$

$$e_t = e_0 + f_1 u_t + f_2 u_{t-1} + f_3 u_{t-2} + f_4 u_{t-3} + f_5 u_{t-4} + f_6 u_{t-5} + \sum_{i=6}^{\infty} u_{t-i} \tag{3.9}$$

$$w_t = w_0 + k_2 u_{t-1} + k_3 u_{t-2} + k_4 u_{t-3} + k_5 u_{t-4}$$

$$+ k_6 u_{t-5} + \sum_{i=6}^{\infty} u_{t-i} \qquad (3.10)$$

$$i_t = i_0 + h_1 u_t + h_2 u_{t-1} + h_3 u_{t-2} + h_4 u_{t-3}$$

$$+ h_5 u_{t-4} + h_6 u_{t-5} \qquad (3.11)$$

$$T_t = T_0 + g_1 u_t + g_2 u_{t-1} + g_3 u_{t-2} + g_4 u_{t-3}$$

$$+ g_5 u_{t-4} + g_6 u_{t-5} \qquad (3.12)$$

where

$$f_1 = \frac{(1 - a_2)(1 + b_1 \frac{A_2}{d}) - a_1 b_1}{-a_3 b_1 (1 + b_1 \frac{A_2}{d})} \qquad (3.13)$$

$$f_2 = \frac{[(1 - a_2 + a_{10})\frac{A_2}{d} + (a_4 - a_3)](1 + b_1 \frac{A_3}{d}) - a_1 b_1 \frac{c_2}{d}}{(a_4 - a_3)(1 + b_1 \frac{A_2}{d})(1 + b_1 \frac{A_3}{d})} , \qquad (3.14)$$

$$f_3 = \frac{[(1 - a_2 + a_{10} + a_{11})\frac{A_3}{d} + a_5 + a_4 - a_3](1 + b_1 \frac{A_4}{d}) - a_1 b_1 \frac{c_3}{d}}{(a_5 + a_4 - a_3)(1 + b_1 \frac{A_3}{d})(1 + b_1 \frac{A_4}{d})} ,$$

$$f_4 = \frac{[(1 - a_2 + a_{10} + a_{11})^{\frac{A_4}{d}} + a_6 + a_5 + a_4 - a_3](1 + b_1^{\frac{A_5}{d}}) - a_1 b_1^{\frac{c_4}{d}}}{(a_6 + a_5 + a_4 - a_3)(1 + b_1^{\frac{A_4}{d}})(1 + b_1^{\frac{A_5}{d}})},$$

$$f_5 = \frac{[(1 - a_2 + a_{10} + a_{11} + a_{12})^{\frac{A_5}{d}} + a_7 + a_6 + a_5 + a_4 - a_3](1 + b_1^{\frac{A_5}{d}}) - a_1 b_1^{\frac{c_5}{d}}}{(a_7 + a_6 + a_5 + a_4 - a_3)(1 + b_1^{\frac{A_5}{d}})(1 + b_1^{\frac{A_6}{d}})},$$

$$f_6 = \frac{[(1 - a_2 + a_{10} + a_{11} + a_{12} + a_{13} + a_{14})^{\frac{A_6}{d}} + a_8 + a_7 + a_6 + a_5 + a_4 - a_3] - a_1 b_1^{\frac{c_6}{d}}}{(a_8 + a_7 + a_6 + a_5 + a_4 - a_3)(1 + b_1^{\frac{A_6}{d}})},$$

$$f_7 = f_8 = \ldots = 1;$$

where

$$A_2 = c_6 + c_5 + c_4 + c_3 + c_2,$$

$$A_3 = c_6 + c_5 + c_4 + c_3,$$

$$A_4 = c_6 + c_5 + c_4,$$

$$A_5 = c_6 + c_5,$$

$$A_6 = c_6;$$

$$\beta_1 = 0, \qquad \beta_2 = \frac{1 + b_2(f_3 - f_2)}{1 + b_1 \frac{A_2}{d}}$$

$$\beta_3 = \frac{1 + b_2(f_4 - f_3)}{1 + b_1 \frac{A_3}{d}}, \qquad \beta_4 = \frac{1 + b_2(f_5 - f_4)}{1 + b_1 \frac{A_4}{d}}$$

$$\beta_5 = \frac{1 + b_2(f_6 - f_5)}{1 + b_1 \frac{A_5}{d}}, \qquad \beta_6 = \frac{1 + b_2(1 - f_6)}{1 + b_1 \frac{A_6}{d}}$$

$$\beta_7 = \beta_8 = \ldots = 1;$$

$$\alpha_1 = \frac{1}{b_1}[1 + b_2(f_2 - f_1)], \qquad \alpha_2 = \frac{1}{d} A_2\beta_2$$

$$\alpha_3 = \frac{1}{d} A_3\beta_3, \qquad \alpha_4 = \frac{1}{d} A_4\beta_4, \qquad \alpha_5 = \frac{1}{d} A_5\beta_5$$

$$\alpha_6 = \frac{1}{d} A_6\beta_6, \qquad \alpha_7 = \alpha_8 = \ldots = 0;$$

$$k_1 = 0, \qquad k_2 = (1 - A_2)\beta_2, \qquad k_3 = (1 - A_3)\beta_3$$

$$k_4 = (1 - A_4)\beta_4, \qquad k_5 = (1 - A_5)\beta_5$$

$$k_6 = (1 - A_6)\beta_6, \qquad k_7 = k_8 = \ldots = 1$$

$$k_7 > k_6 > k_5 > k_4 > k_3 > k_2 > k_1;$$

$$h_1 = f_2 - f_1, \qquad h_2 = f_3 - f_2, \qquad h_3 = f_4 - f_3$$

$$h_4 = f_5 - f_4, \quad h_5 = f_6 - f_5, \quad h_6 = 1 - f_6$$

$$h_7 = h_8 = \ldots = 0;$$

$$g_1 = -a_3 f_1$$

$$g_2 = (a_4 - a_3)(f_2 - \beta_2) - a_{10}\alpha_2,$$

$$g_3 = (a_5 + a_4 - a_3)(f_3 - \beta_3) - (a_{10} + a_{11})\alpha_3,$$

$$g_4 = (a_6 + a_5 + a_4 - a_3)(f_4 - \beta_4) - (a_{10} + a_{11} + a_{12})\alpha_4,$$

$$g_5 = (a_7 + a_6 + a_5 + a_4 - a_3)(f_5 - \beta_5)$$

$$- (a_{10} + a_{11} + a_{12} + a_{13})\alpha_5$$

$$g_6 = (a_8 + a_7 + a_6 + a_5 + a_4 - a_3)(f_6 - \beta_6)$$

$$- (a_{10} + a_{11} + a_{12} + a_{13} + a_{14})\alpha_6$$

$$g_7 = g_8 = \ldots = 0;$$

$$y_0 = \bar{y}, \quad i_0 = i^*, \quad p_0 = -b_0 + b_2 i_0 - b_1 y_0$$

$$e_0 = \frac{(1 - a_2 + a_{10})\bar{y} - a_0 + a_1 i^*}{a_9 + a_8 + a_7 + a_6 + a_5 + a_4 - a_3} + p_0$$

$$T_0 = (a_9 + a_8 + a_7 + a_6 + a_5 + a_4 - a_3)(e_0 - p_0) - a_{10}y_0;$$

Before interpreting the solution for the model, it is very useful to note that there are some restrictions on the values of the a_i's. Since equation (3.1) is a second order dynamic expectational difference equation, there are two characteristic roots.[2] To get a unique solution for the free parameters, we restrict the two roots to be greater than unity in absolute value. Now if the unique solution for the rational expectations model exists, the following restrictions on the a_i's can be shown to hold.

$$a_3 > \frac{2\{b_2[(1-a_2)(1+b_1 \frac{A_2}{d})+a_1 b_1]+a_1 b_1(1+b_1 \frac{A_2}{d})\}}{b_1(1+b_1 \frac{A_2}{d})} \qquad (3.15)$$

$$a_4-a_3 < \frac{\begin{array}{c}-2\{b_2[(1-a_2+a_{10})\frac{A_2}{d} +a_1+a_4-a_3](1+b_1 \frac{A_3}{d}) \\ +a_1 b_2(1+b_1 \frac{A_2}{d})+a_1(1+b_1 \frac{A_2}{d})(1+b_1 \frac{A_3}{d})\}\end{array}}{(1+b_1 \frac{A_2}{d})(1+b_1 \frac{A_3}{d})}$$

$$\text{if } a_4-a_3 < 0; \qquad (3.16)$$

$$a_5+a_4-a_3 < \frac{\begin{array}{c}-2\{b_2[(1-a_2+a_{10}+a_{11})\frac{A_3}{d}+a_1+a_5+a_4-a_3](1+b_1\frac{A_4}{d})\\ +a_1b_2(1+b_1\frac{A_3}{d})+a_1(1+b_1\frac{A_3}{d})(1+b_1\frac{A_4}{d})\}\end{array}}{(1+b_1\frac{A_3}{d})(1+b_1\frac{A_4}{d})}$$

if $a_5+a_4-a_3 < 0$; (3.17)

$$\begin{array}{l}a_6+a_5\\ a_4-a_3\end{array} < \frac{\begin{array}{c}-2\{b_2[(1-a_2+a_{10}+a_{11}+a_{12})\frac{A_4}{d}+a_1+a_6+a_5+a_4-a_3](1+b_1\frac{A_5}{d})\\ +a_1b_2(1+b_1\frac{A_4}{d})+a_1(1+b_1\frac{A_4}{d})(1+b_1\frac{A_5}{d})\}\end{array}}{(1+b_1\frac{A_4}{d})(1+b_1\frac{A_5}{d})}$$

if $a_6+a_5+a_4-a_3 <0$; (3.18)

$$\begin{array}{l}a_7+a_6\\ a_5+a_4-a_3\end{array} < \frac{\begin{array}{c}-2\{b_2[(1-a_2+a_{10}+a_{11}+a_{12}+a_{13})\frac{A_5}{d}+a_1+a_7+a_6+a_5+a_4-a_3]\\ \times\ (1+b\frac{A_6}{d})+a_1b_2(1+b_1\frac{A_5}{d})+a_1(1+b_1\frac{A_5}{d})(1+b_1\frac{A_6}{d})\}\end{array}}{(1+b_1\frac{A_5}{d})(1+b_1\frac{A_6}{d})}$$

if $a_7+a_6+a_5+a_4-a_3 < 0$; (3.19)

$$\begin{array}{l}a_8+a_7+a_6\\ +a_5+a_4-a_3\end{array} < \frac{\begin{array}{c}-2\{b_2[(1-a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14})\frac{A_6}{d}+a_1+a_8+a_7+a_6\\ +a_5+a_4-a_3]\ \times\ (1+b_1\frac{A_6}{d})+a_1b_2(1+b_1A_5)+a_1(1+b_1A_6)\}\end{array}}{(1+b_1\frac{A_6}{d})}$$

if $a_8+a_7+a_6+a_5+a_4-a_3 < 0$ (3.20)

$$a_9+a_8+a_7+a_6+a_5+a_4-a_3 <$$

$$-2\{b_2(a_9+a_8+a_7+a_6+a_5+a_4-a_3+a_1)+a_1b_2+a_1\}$$

$$\text{if } a_9+a_8+a_7+a_6+a_5+a_4-a_3 < 0 \qquad (3.21)$$

Generally, the relative price effect on the trade balance may become positive in a couple of periods after an unexpected monetary disturbance, that is, $a_5+a_4-a_3 > 0$, $a_6+a_5+a_4-a_3 > 0$, etc. Therefore, restrictions (3.17) - (3.21) may be seldom needed. But restrictions (3.15) and (3.16) are necessary since $-a_3$ represents J-curve effects and $a_4 < a_3$ because of the plausibly slow adjustment of the trade balance.

As shown in equations (3.8) through (3.10), the system is neutral in the long run with respect to an unanticipated monetary disturbance. That is, the price level, exchange rate and nominal wage increase in the same proportion as the money supply. From equations (3.7), (3.11) and (3.12), output, the interest rate and the trade balance remain unchanged in the long run. Because we assume that the maximum contract period is six, the whole economy attains its new long-run equilibrium exactly six periods after the monetary shock.

3.4 Exchange Rate Dynamics

Under conditions of fixed exchange rates and perfect capital mobility, the exchange rate is exogenous, the supply of money is fully endogenous and monetary policy is not effective at all. But under flexible exchange rates and perfect capital mobility, the supply of money is exogenous and the exchange rate endogenous. The money stock is under the full control of the monetary authorities, and the exchange rate is a main channel through which the effects of the money supply spread to the entire economy. Therefore, we examine the exchange rate dynamics in this chapter and defer a discussion of the trade balance dynamics to the next chapter.

Before we proceed to the discussion of exchange rate dynamics, however, let us first determine the values of the coefficients f_i's.

First, we will prove that the contemporaneous exchange rate countershooting or undershooting is due to the existence of the J-curve effects. Because of equation (3.15), we can suppose that

$$a_3 = \frac{2\{b_2[(1 - a_2)(1 + b_1\frac{A_2}{d}) + a_1b_1] + a_1b_1(1 + b_1\frac{A_2}{d})\}}{b_1(1 + b_1\frac{A_2}{d})} + c$$

Substituting the value of a_3 into equation (3.13), we get the following value of f_1:

$$f_1 = - \frac{(1 - a_2)(1 + b_1\frac{A_2}{d}) - a_1b_1}{[2b_2(1 - a_2) + 2a_1b_1 + cb_1](1 + b_1\frac{A_2}{d}) + 2b_2a_1b_1}$$

Generally, the denominator exceeds the numerator in magnitude. Hence, we can get the result

$$|f_1| < 1 \tag{3.22}$$

Equation (3.13) implies that the contemporaneous exchange rate will not overshoot but countershoot or undershoot. In Appendix C, we prove that if there is no J-curve effect, the restriction on a_3 is that $a_3 > 0$, which implies that f_1 may exceed unity. Hence if the model does not consider J-curve effects, then overshooting may happen. That is consistent with the result from Dornbusch (1976) in which the exchange rate exhibits contemporaneous overshooting behavior. Therefore, we can conclude that a countershooting or undershooting is due to the existence of J-curve effects. In addition, $|f_1| < 1$ also implies that the exchange rate could appreciate or depreciate because of J-curve effects. This surprising result shows that J-curve effects could stabilize the contemporaneous exchange rate movement.

Equation (3.13) indicates that the extent of the countershooting or undershooting is determined by the structural parameters a_1, a_2, a_3, b_1 and A_2. Accordingly, the countershooting or undershooting is larger (i.e., $|f_1|$ is smaller), the larger the income, expected real interest rate and relative price effect on aggregate demand. Also, the countershooting or undershooting is larger, the larger the income effect on money demand and the expected percentage of labor contracts renewals of the next period.

Similarly, if $a_4 - a_3 < 0$, we can use restriction (3.16) to get

$$0 < f_2 < 1 \quad \text{if } a_4 - a_3 < 0 \qquad (3.23)$$ [3]

condition (3.23) implies that the exchange rate undershoots in period 2.

The f_i's are shown to have the following relationships if the relative price effect on the trade balance is positive after period 1 and all denominators are assumed to be positive.

$$f_2>1 \text{ if } A_2[1-a_2+a_{10}-b_1(a_4-a_3)](1+b_1\frac{A_3}{d})-a_1b_1c_2>0, \qquad (3.24)$$

$$f_3>1 \text{ if } A_3[1-a_2+a_{10}+a_{11}-b_1(a_5+a_4-a_3)](1+b_1\frac{A_4}{d})-a_1b_1c_3>0, \qquad (3.25)$$

$f_4>1$ if

$$A_4[1-a_2+a_{10}+a_{11}+a_{12}-b_1(a_6+a_5+a_4-a_3)](1+b_1\frac{A_5}{d})-a_1b_1c_4>0, \qquad (3.26)$$

$f_5>1$ if

$$A_5[1-a_2+a_{10}+a_{11}+a_{12}+a_{13}-b_1(a_7+a_6+a_5+a_4-a_3)](1+b_1\frac{A_6}{d})-a_1b_1c_5>0, \tag{3.27}$$

$f_6>1$ if

$$A_6[1-a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14}-b_1(a_8+a_7+a_6+a_5+a_4-a_3)]-a_1b_1c_6>0, \tag{3.28}$$

$f_2>f_3$ if

$$a_5 > \frac{(a_4-a_3)\{b_1c_2(a_4-a_3)+a_{11}A_3(1+b_1A_2)+a_1b_1[c_2(a_{10}-a_2)+c_3\frac{1+b_1\frac{A_2}{d}}{1+b_1\frac{A_4}{d}}]\}}{(1-a_2+a_{10})(1+b_1A_3)A_2-(a_1+a_4-a_3)b_1c_2} \tag{3.29}$$

$f_3>f_4$ if

$$a_6 > \frac{(a_5+a_4-a_3)\{b_1c_3(a_5+a_4-a_3)+a_{12}A_4(1+b_1A_3)+a_1b_1[c_3(a_{10}+a_{11}-a_2)+c_4\frac{1+b_1\frac{A_3}{d}}{1+b_1\frac{A_5}{d}}]\}}{(1-a_2+a_{10}+a_{11})(1+b_1A_4)A_3-(a_5+a_4+a_1-a_3)b_1c_3} \tag{3.30}$$

$f_4>f_5$ if

$$a_7 > \frac{(a_6+a_5+a_4-a_3)\{b_1c_4[a_6+a_5+a_4-a_3)+a_{13}A_5(1+b_1A_4)+a_1b_1[c_4(a_{10}+a_{11}+a_{12}-a_2)+c_5\frac{1+b_1\frac{A_4}{d}}{1+b_1\frac{A_6}{d}}]\}}{(1-a_2+a_{10}+a_{11}+a_{12})(1+b_1A_5)A_4-(a_6+a_5+a_4-a_3)b_1c_4} \tag{3.31}$$

$f_5 > f_6$ if

$$a_8 > \frac{(a_7+a_6+a_5+a_4-a_3)\{b_1c_5(a_7+a_6+a_5+a_4-a_3)+a_{14}A_6(1+b_1A_5) +a_1b_1[c_5(a_{10}+a_{11}+a_{12}+a_{13}-a_2)+c_6(1+b_1\frac{A_5}{d})]\}}{(1-a_2+a_{10}+a_{11}+a_{12}+a_{13})(1+b_1A_6)A_5-(a_7+a_6+a_5+a_4-a_3)b_1c_5} \tag{3.32}$$

If the denominators are negative, f_{i+1} will exceed f_i. Generally, in several periods after the monetary disturbances, the denominators are more likely to be negative. An explanation is given below.

The determinants of the values of the other f's include those of f_1, contemporaneous renewal percentages of labor contracts, the income effect on import demand and the increasing relative price effect on the trade balance. All the parameters are fixed over time except the relative price and income effects on the trade balance and the renewal rate of labor contracts. That implies that only the increasing relative price and income effects on the trade balance and the increasing percentages of renewed labor contracts matter in the intermediate run. The other parameters matter just in the short run and in the long run. The exchange rate could overshoot to the highest level in the third period after the unanticipated monetary disturbance if $a_5 + a_4 - a_3$ is positive and small. However, as in section 2.3, although the income effect boosts the overshooting, both the relative price effects and the renewals of labor contracts increase over time and their increases dampen the overshooting dominantly and increasingly. Because of the interplay of labor and trade contracts, the overshooting of the exchange rate decreases over time. The increases may make conditions (3.30), (3.31) or (3.32) fail. That is, the exchange rate in the last two periods may reverse the overshooting to undershooting, then approach the long-run equilibrium.

Price adjustment depends on b_1, b_2, contemporaneous wage adjustment, f_t and f_{t+1}. Accordingly, the price inflation is larger, the larger the interest rate elasticity of money demand and the expected exchange rate elasticity of the monetary disturbance for the next period, and the smaller the contemporaneous exchange rate elasticity of the money supply and the contemporaneous nonrenewal rate of labor contracts. Since parameters b_1 and b_2 are fixed over time, the price adjustment paths in the intermediate run are affected by the exchange rate path and the consecutive renewal of labor contracts. Generally, the exchange rate overshoots for a while after period 1, and then undershoots in the last couple of periods. Labor contract renewals increase over time. Therefore, the price level could increase monotonically if f_2 is not undershooting.

In the following figures, A represents the initial equilibrium, B the first period position, C the second period position, D undershooting and E the new equilibrium. Using equations (3.22) - (3.32) and the solution for the price adjustment paths, we will illustrate both implausible and plausible time paths for (e_t, p_t). Case A in Figure 3.1 is the implausible one. Because of J-curve effects on the trade balance, a contemporaneous overshooting of the exchange rate is unlikely in this model. If J-curve effects are dropped from the model, the path toward its long-run equilibrium is possible because of the significant interplay of trade contracts and labor contracts in the intermediate run.

Case B and case C are not very plausible either, since case B supposes the relative price effects increase so fast that conditions (3.24) - (3.32) do not hold, and case C ignores the interplay of trade and labor contracts.

Case D, case E and case F are the most likely ones. They depend on the values of a_1, a_2 and b_1, especially a_1. In case D, the real interest rate effect on aggregate demand, a_1, is relatively large and $0<f_1<1$. In case E, a_1 is relatively small and $-1<f_1<0$. In Figure 3.5, there are two alternative paths from D to E. One crosses the 45° line, that is, the price elasticity of the monetary disturbance exceeds its exchange rate elasticity in the last couple of periods. The other one moves under and

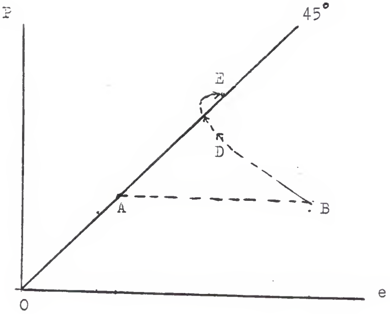

Figure 3.1. Case A: if conditions (3.24) - (3.26) and (3.29) - (3.31) hold, but (3.22), (3.23), (3.27), (3.28) and (3.32) do not.

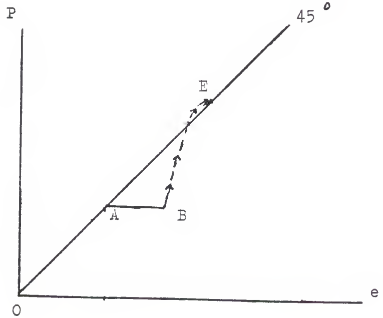

Figure 3.2. Case B: if conditions (3.22) and (3.23) hold, but (3.24) - (3.32) do not.

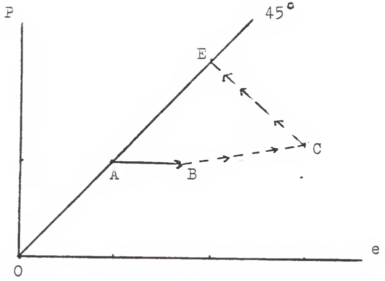

Figure 3.3. Case C: if conditions (3.22) and (3.24) - (3.32) hold, but (3.23) does not.

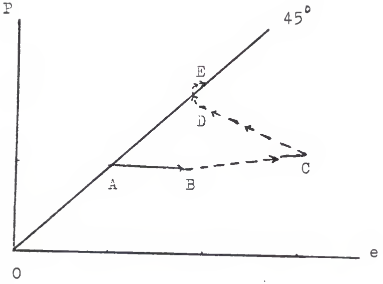

Figure 3.4. Case D: if conditions (3.22), (3.24) - (3.26) and (3.29) - (3.31) hold, but (3.23), (3.27), (3.28) and (3.32) do not.

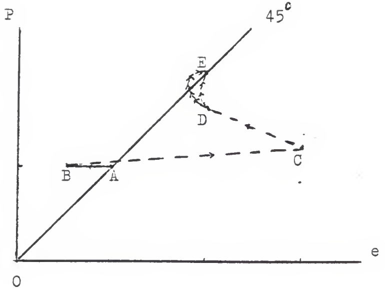

Figure 3.5. Case E: same as case D except a contemporaneous appreciation.

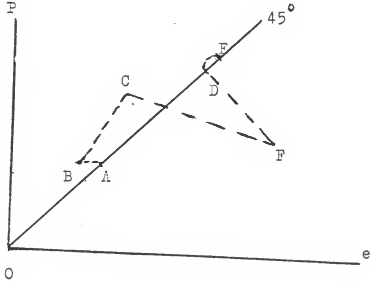

Figure 3.6. Case F: same as case E except an undershooting in period 2.

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along the 45^{o} line and its meaning is just the opposite. Case E generates a contemporaneous countershooting or appreciation of the exchange rate after an unanticipated monetary disturbance that is consistent with the monetary approach to exchange rate dynamics in the literature, since most authors did not consider both the J-curve effects and the intermediate run in their models. Examples are Dornbusch (1976), Driskill (1981a) and Niehans (1977). The J-curve effects could surprisingly restrain the volatile movement of the exchange rate in the short run. In the intermediate run, the interplay of trade contracts and labor contracts plays a major role and they could reverse overshooting to undershooting in the last two periods. Basically, case F is the same as case E except in period 2. Case F is an example of slow adjustment of the trade balance. The exchange rate undershoots. Price jumps to a high level in period 2, but decreases in period 3 and then increases to the long-run level. The price adjustment is not monotonic.

We conclude that even under the assumption of perfect capital mobility and substitutability, the model incorporating the J-curve effects, trade contracts and labor contracts can generate more complex nonmonotonic patterns of exchange-rate adjustments than those in Dornbusch (1976).

Since the value of a_1 is generally relatively small, the most likely time path of the exchange rate generated by this chapter is case F, namely, a countershooting in period 1, undershooting in period 2, overshooting for the next two periods, then undershooting in the last two periods.

3.5 Output, Wage and Interest Rate Adjustments

After we have examined the time paths of the exchange rate and price level, we can use them to explain the adjustment process for output, the nominal wage and the real interest rate.

Under flexible exchange rates, the initial effects on output of an unexpected monetary disturbance differ from that of an exchange rate disturbance under fixed exchange rates. Under fixed exchange rates, if J-curve effects dominate the expected real interest rate effect, output is contractionary in the first period. But under flexible exchange rates, since J-curve effects restrain the volatile exchange rate (due to the monetary disturbance) from overshooting, and the expected undershooting or overshooting in the second period reinforces or dominates the contemporaneous countershooting or undershooting, output in the first period expands at a great rate. But it also depends on the income and the interest rate effect on money demand. The extent of output increase is larger, the smaller is the income effect on money demand, and the larger is the interest rate effect on money demand. However, the extent of the wage increase is equal to the extent of the price inflation times the percentage of labor contracts renewed. Price increases at an increasing rate during the first two periods, then at a decreasing rate during the last two periods, and the renewal rate of labor contracts increases over time. Therefore, the nominal wage increases steadily to the new long-run level.

For the interest rate, the adjustment process depends on the expected rate of depreciation or appreciation. In the first period, since the expected undershooting or overshooting of the exchange rate in period 2 reinforces or outweighs the contemporaneous countershooting or undershooting owing to J-curve effects, the interest rate increases surprisingly. After that, it may fall below the initial level in the remaining periods and then return to the initial level in the long run. But when the exchange rate undershoots in the last two periods, the interest rate first will increase and then return to its initial level.

Notes

[1] Bilson (1978) used data on the deutche mark/pound exchange rate over the period from June 1970-August 1977; his estimates tend to confirm the predictions of the Dornbusch model (1976). Frenkel (1976) used the time series of the monthly logarithms of the German money supply and the mark/dollar exchange rate for the period February

1920-November 1923; he found that a high supply of marks was associated with mark depreciation. Although their empirical results were consistent with the theoretical prediction of the Dornbusch model (1976) under certain circumstances, the countries they chose for estimation were large countries, such as the US, Germany and Britain, which is not consistent with the assumption of the small country case made in the Dornbusch model. Besides, the German hyperinflation during 1920-1923 happened under fixed exchange rates, not under flexible exchange rates. Therefore, more empirical work is required before the predictions of the Dornbusch model can be considered confirmed.

[2] If we denote the expected real interest rate in equation (3.1), by x_t, i.e., $x_t = i_t - {}_tp_{t+1} + p_t$, and substitute i_t and p_t from equation (3.3) and (3.2) into x_t, we get

$$x_t = i^* + m_t - {}_tm_{t+1} - b_1y_t + b_2\,{}_ty_{t+1} - (1 + b_2)e_t + (1 - 2b_2)\,{}_te_{t+1} - b_2\,{}_te_{t+2},$$

which is a second order expectational difference equation in e_t.

[3] As in proving $|f_1|<1$, we can plug (3.16) into (3.14) and get the following

$$f_2 = \frac{\left\{(1-a_2+a_{10})\frac{A_2}{d}(1+b_1\frac{A_2}{d})(1+b_1\frac{A_3}{d}) - 2b_2[(1-a_2+a_{10})\frac{A_2}{d} + a_1 + a_4 - a_3](1+b_1\frac{A_3}{d}) - 2a_1b_2(1+b_1\frac{A_2}{d}) - 2(c+a_1)(1+b_1\frac{A_2}{d})(1+b_1\frac{A_3}{d})\right\}(1+b_1\frac{A_3}{d}) - a_1b_1\frac{c_2}{d}(1+b_2\frac{A_2}{d})(1+b_1\frac{A_3}{d})}{-2\left\{b_2[(1-a_2+a_{10})\frac{A_2}{d} + a_1 + a_4 - a_3](1+b_1\frac{A_3}{d}) + a_1b_2(1+b_1\frac{A_2}{d}) + (c+a_1)(1+b_1\frac{A_2}{d})(1+b_1\frac{A_3}{d})\right\}(1+b_1\frac{A_2}{d})(1+b_1\frac{A_3}{d})}$$

Since $2(1+a_1)(1+b_1\frac{A_2}{d})(1+b_1\frac{A_3}{d})$ generally exceeds $(1-a_2+a_{10})\frac{A_2}{d}(1+b_1\frac{A_3}{d})$ and the denominator is greater than the numerator, we can get the result of equation (3.23), that is, $0 < f_2 < 1$ if $a_4 - a_3 < 0$.

CHAPTER 4

UNANTICIPATED MONETARY DISTURBANCES AND TRADE BALANCE DYNAMICS UNDER FLEXIBLE EXCHANGE RATES

4.1 Introduction

Trade balance and exchange rate dynamics are determined by the entire economy in a rational expectations model. After having examined the exchange rate dynamics in Chapter 3, we will use results derived there to investigate trade balance dynamics after an unanticipated increase in money supply.

It will be shown that J-curve effects could surprisingly improve the trade balance in the short run due to the reversal of J-curve effects. Under flexible exchange rates, the trade balance may reach the highest position in the first period. After that, in the intermediate run, the trade balance decreases gradually until it falls below the initial level, then increases gradually to the long-run level.

In the next section, trade balance dynamics are discussed. Section 4.3 derives three special cases from the model, one of which is the Dornbusch model. Section 4.4 shows six numerical simulations from which we could compare partially the results from the model with those from the special cases. Conclusions are contained in section 4.5.

4.2 Trade Balance Dynamics

As we mentioned before, the fixed parameters of the model determine the time paths of prices and the exchange rate in the short run and the long run. But in the intermediate run, trade and labor contracts play a decisive role. That also applies to the trade balance adjustment process. In this section, we use information about the time paths of the exchange rate and price level to explain trade balance dynamics.

The J-curve effects are significant because of restriction (3.15). But when the real interest rate elasticity of aggregate demand is relatively small, f_1 could be negative. A countershooting of the exchange rate in the first period creates the reversal of J-curve effects on the trade balance. And the trade balance could jump to its largest surplus level in the first period.

In the intermediate run, the behavior of the exchange rate and price level determines trade balance dynamics. As in the case of fixed exchange rates, the increasing relative price effect on the trade balance has positive effects on the g_i's, but under flexible exchange rates, they also have negative effects on the g_i's through dampening of the overshootings of the exchange rate and raising of the price level. Hence, their net effects on the g_i's may be ambiguous, depending on the structure of the parameter values. In addition, the behavior of the exchange rate and price level in the intermediate run is also affected steadily and gradually by the consecutive renewal of labor contracts. Accordingly, the behavior of the exchange rate and price level actually will dominate the trade balance dynamics in the intermediate run.

After the first period, owing to the interplay of the trade and labor contracts, the trade balance may decrease monotonically. When the paths of (e_t, p_t) cross the 45^o line, the trade balance becomes worse than the initial level. The negative income effects may now dominate the time path of the trade balance. However, after six periods, the trade balance returns to the initial level, and from then on the monetary disturbance loses its effect completely.

Using Figures 4.1 to 4.5, we will illustrate some plausible and implausible time paths for the trade balance. The path in Figure 4.1 is less plausible under flexible exchange rates, but it is the most likely one under fixed exchange rates. The difference lies in the differential role played by the expected relative price effect on the trade balance under different exchange

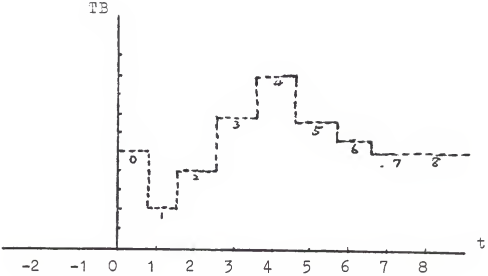

Figure 4.1. Implausible path for the trade balance.

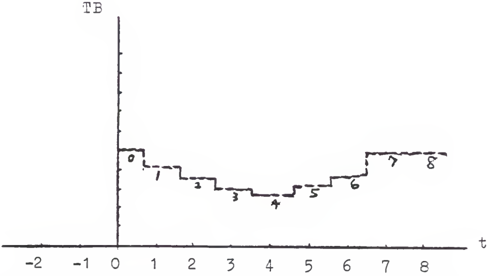

Figure 4.2. Implausible path for the trade balance.

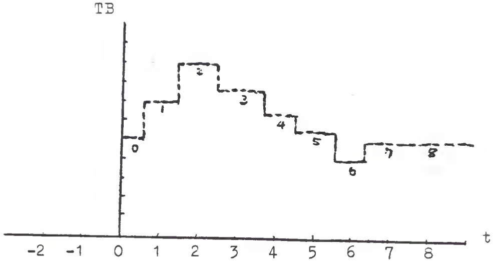

Figure 4.3. A plausible path for the trade balance.

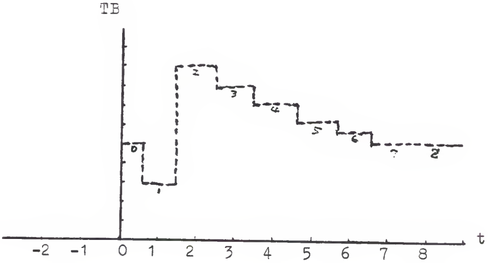

Figure 4.4. A plausible path for the trade balance.

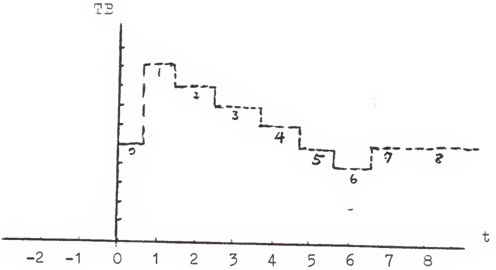

Figure 4.5. A most likely path for the trade balance.

rates regimes. Under fixed exchange rates, the increasing expected price effect has unambiguously positive effects on the trade balance. But under flexible exchange rates, the net effect is ambiguous owing to its dampening of the overshooting of the exchange rate. The path in Figure 4.2 is equally implausible because the relative price effect increases at an incredible pace and the consecutive renewal rates of labor contracts in the first couple of periods are too high.

The paths in Figures 4.3, 4.4 and 4.5 are plausible. In Figure 4.4, after J-curve effects, the trade balance reaches its highest position in the second period, then decreases monotonically thereafter. But for the path in Figure 4.3 and 4.5, the path of (e_t, p_t) crosses the 45^o line due to the significant interplay of the long-term trade and labor contracts. In Figures 4.3 and 4.5, we incorporate the case of the reversal of the J-curve effects into the time path of the trade balance. In reality, the path in Figure 4.5 may be the most likely one because of significant J-curve effects and the possible contemporaneous countershooting of the exchange rate after an unanticipated increase in the money supply under flexible exchange rates.

4.3 Three Special Cases

4.3.1 The Case of Dornbusch (1976)

We now proceed to compare the above general solution with the solutions for three special cases. In case one, we suppose that all trade contracts have no delivery lag and we do not consider J-curve effects on the trade balance, that is, $-a_3$ becomes a_3. Labor contracts are assumed to last one period.

The solution for case one is the following:

$$f_1 = \frac{(1 - a_2) - a_1 b_1}{a_3 b_1}, \qquad f_2 = f_3 = \dots = 1;$$

$$\beta_1 = 0, \qquad \beta_2 = \beta_3 = \dots = 1;$$

$$\alpha_1 = \frac{1 + b_2(1 - f_1)}{b_1}, \qquad \alpha_2 = \alpha_3 = \ldots = 0;$$

$$k_1 = 0, \qquad k_2 = k_3 = \ldots = 1;$$

$$h_1 = 1 - f_1, \qquad h_2 = h_3 = \ldots = 0;$$

$$g_1 = a_3 f_1, \qquad g_2 = g_3 = \ldots = 0.$$

Case one is basically the case of Dornbusch (1976). Dornbusch indicated that the cause of exchange rate instability is the differential speed of adjustment between commodity and asset markets. With price fixed in the short run, an unanticipated monetary disturbance must be accompanied by a fall in the nominal rate of interest. In view of equation (3.3), this implies that the contemporaneous exchange rate must depreciate by more than the long-run rate. Rational expectations then require that the spot rates appreciate during the period of price adjustment, so that the rate must have initially depreciated by more than in proportion to the increase in the money supply. Dornbusch's model is the short-run and long-run analysis without the intermediate run since all of the parameters in his model are fixed over time.

Let us turn to the explanation of the above solution. In the short run, the contemporaneous overshooting of the exchange rate is possible now, since the restriction on the relative price effect on the trade balance is $a_3 > 0$, not equation (3.15). Therefore, if the expected real interest rate effect on aggregate demand is not very large, case one could generate contemporaneous overshooting of the exchange rate. The extent of the overshooting is larger, the smaller are the expected real interest rate effect, relative price effect and income effect on aggregate demand, and the smaller is the income effect on money demand. In the long run, the second period, the exchange rate will rise in the same proportion as the money supply. The price level is unchanged in the short run, but moves gradually to the long-run level in the second period. The long-run equilibrium price level will also rise in the same proportion as the money supply. The interest rate falls in the short run due to the increase in the nominal money supply, but returns to its initial level in the long run. The nominal wage is given too in the first period, but adjusts fully and suddenly in the long run owing to one-period labor contracts. The reduction in the interest rate and the overshooting that will immediately occur raise demand for domestic output and output increases. The extent of output increase is larger, the smaller are the interest rate and income effect on money demand. In the long run, output is not changed. Since case one does not consider J-curve effects the trade balance improves in the short

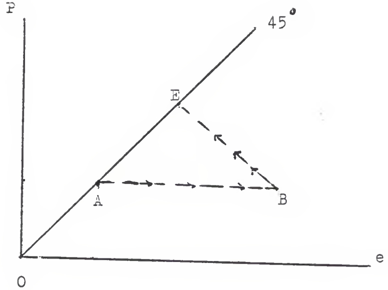

Figure 4.6. The path of (e_t, p_t) for special case one.

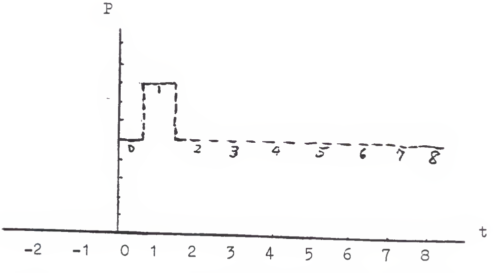

Figure 4.7. The trade balance path for special case one.

run, but returns to its initial level in the long run. The paths of (e_t, p_t) and of the trade balance relating to case one are described in Figures 4.6 and 4.7.

Since all the results in this case are identical to those of Dornbusch's model, we can claim that Dornbusch's model is a special case of our general model. An important implication is that if the case of Dornbusch (1976) is normal when J-curve effects are absent, then the paths in case E and F of Chapter 3 are also normal if the J-curve effects are significant.[1]

4.3.2 The Case of Ueda (1983)

In case two, we assume all trade contracts have one-period lags and all traders form their prior expectations at period t-1. For labor contracts, they are assumed to run for two periods. The purpose of these assumptions is to reduce the general model in Chapter 3 to the model of Ueda (1983).[2]

The solution for case two is the following:

$$f_1 = \frac{(1 - a_2)(1 + b_1\frac{c_2}{d}) - a_1 b_1}{-a_3 b_1 (1 + b_1\frac{c_2}{d})}$$

$$f_2 = \frac{[(1 - a_2 + \bar{a}_{10})\frac{c_2}{d} + \bar{a}_4 - a_3] - a_1 b_1\frac{c_2}{d}}{(\bar{a}_4 - a_3)(1 + b_1\frac{c_2}{d})}$$

$$f_3 = f_4 = \ldots = 1;$$

$$\beta_1 = 0, \qquad \beta_2 = \frac{1 + b_2(1 - f_2)}{1 + b_1\frac{c_2}{d}}$$

$$\beta_3 = \beta_4 = \ldots = 1;$$

$$\alpha_1 = \frac{1}{b_1}\,[1 + b_2\,(f_2 - f_1)], \qquad \alpha_2 = \frac{1}{d}\,c_2\beta_2$$

$$\alpha_3 = \alpha_4 = \ldots = 0;$$

$$h_1 = f_2 - f_1, \qquad h_2 = 1 - f_2$$

$$h_3 = h_4 = \ldots = 0;$$

$$k_1 = 0, \qquad k_2 = c_1\beta_2, \qquad k_3 = k_4 = \ldots = 1;$$

$$g_1 = -a_3 f_1, \qquad g_2 = (\bar{a}_4 - a_3)(f_2 - \beta_2) - \bar{a}_{10}\alpha_2,$$

$$g_3 = g_4 = \ldots = 0;$$

$$a_3 > \frac{2\{b_2[(1 - a_2)(1 + b_1\frac{c_1}{d}) + a_1b_1] + a_1b_1(1 + b_1\frac{c_1}{d})\}}{b_1(1 + b_1\frac{c_1}{d})};$$

$$\bar{a}_4 - a_3 > 0.$$

The last two inequalities are the restrictions on a_i's for the unique solution of the rational expectations model.

Case two is the whole run analysis. Period 1 represents the short run, period 2 the intermediate run, period 3 the long run. But the problem with case two is that the intermediate run is too short to distinguish likely from less likely time paths for the endogenous variables during the adjustment process.

Let us explain the above solution. Owing to the assumption that all trade contracts have one-period lags, the value of $\bar{a}_4$ should be equal to the sum of the rest of the a_i's, $\bar{a}_4 = a_4 + a_5 + a_6 + a_7 + a_8 + a_9$. The value of $\bar{a}_4$ is large relative to the value of a_4 in the general model. In the first period, the exchange rate may countershoot or undershoot, and price and wage are fixed. The interest rate may increase because of the expected depreciation of the exchange rate in the next period. Output increases, and the trade balance improves due to the countershooting of the exchange rate.

In the second period, given the large value of $\bar{a}_4$, the exchange rate may undershoot. The price inflation may increase more slowly than the depreciation of the exchange rate. Hence, the path of (e_t, p_t) may cross the 45^o line, and the trade balance may still be positive. But since income effects dominate the trade balance, the surplus begins to decline. These are demonstrated in Figure 4.8 and 4.9. The interest rate may still increase because the long-run exchange rate is expected to depreciate further. Wage and output increase.

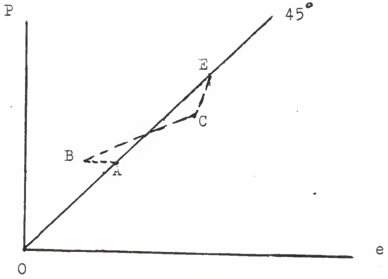

Figure 4.8. The path of (e_t, p_t) for special case two.

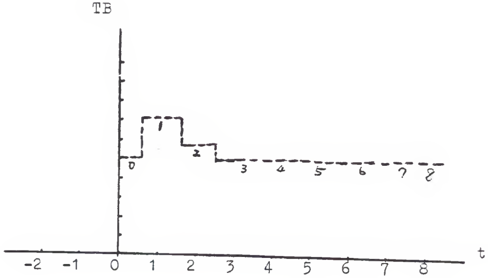

Figure 4.9. The trade balance path for special case two.

In the third period, the entire economy is neutral with respect to the monetary disturbance. It returns to the long-run equilibrium.

The explanation given above is different from that of Ueda (1983). The difference arises from different restrictions that were imposed on a_3 and $\bar{a}_4$. Ueda (1983) did not find the restriction on a_3 owing to the J-curve effect under rational expectations. Therefore, his results for period 1 and period 2 are almost completely different from those of this special case two.[3]

4.3.3 Case Three

In case three, we assume that all labor contracts run for six periods, as in the general model. But for the trade contracts, the assumption is identical to that of case three in section 2.3.3, that is, some trade contracts have one-period delivery lags and the others have a lag of two periods. These assumptions are used to reflect countries in which the length of labor contracts is three times that of trade contracts.

The solution for the case is as follows:

$$f_1 = \frac{(1 - a_2)(1 + b_1\frac{A_2}{d}) - a_1 b_1}{-a_3 b_1 (1 + b_1\frac{A_2}{d})} ,$$

$$f_2 = \frac{[(1 - a_2 + a_{10})\frac{A_2}{d} + a_4 - a_3](1 + b_1\frac{A_3}{d}) - a_1 b_1\frac{c_2}{d}}{(a_4 - a_3)(1 + b_1\frac{A_2}{d})(1 + b_1\frac{A_3}{d})} ,$$

$$f_3 = \frac{[(1 - a_2+a_{10}+a_{11})\frac{A_3}{d} + a_5+a_4-a_3)(1 + b_1\frac{A_4}{d}) - a_1b_1\frac{c_3}{d}}{(a_5 + a_4 - a_3)(1 + b_1\frac{A_3}{d})(1 + b_1\frac{A_4}{d})} ,$$

$$f_4 = \frac{[(1 - a_2+a_{10}+a_{11})\frac{A_4}{d} +a_5+a_4-a_3](1 + b_1\frac{A_5}{d}) - a_1b_1\frac{c_4}{d}}{(a_5 +a_4 - a_3)(1 + b_1\frac{A_4}{d})(1 + b_1\frac{A_5}{d})} ,$$

$$f_5 = \frac{[(1 - a_2+a_{10}+a_{11})\frac{A_5}{d} +a_5+a_4-a_3](1 + b_1\frac{A_6}{d}) - a_1b_1\frac{c_5}{d}}{(a_5 + a_4 - a_3)(1 + b_1\frac{A_5}{d})(1 + b_1\frac{A_6}{d})} ,$$

$$f_6 = \frac{[(1 - a_2 + a_{10} + a_{11})\frac{A_6}{d} + a_5 + a_4 - a_3] - a_1b_1\frac{c_6}{d}}{(a_5 + a_4 - a_3)(1 + b_1\frac{A_6}{d})} ,$$

$$f_7 = f_8 = \dots = 1;$$

$$\beta_1 = 0, \quad \beta_2 = \frac{1 + b_2(f_3 - f_2)}{1 + b_1\frac{A_2}{d}} , \quad \beta_3 = \frac{1 + b_2(f_4 - f_3)}{1 + b_1\frac{A_3}{d}} ,$$

$$\beta_4 = \frac{[1 + b_2(f_5 - f_4)]}{1 + b_1\frac{A_4}{d}} , \quad \beta_5 = \frac{[1 + b_2[f_6 - f_5)]}{1 + b_1\frac{A_5}{d}} ,$$

$$\beta_6 = \frac{1 + b_2(1 - f_6)}{1 + b_1\frac{A_6}{d}} , \quad \beta_7 = \beta_8 = \dots = 1;$$

$$\alpha_1 = \frac{1}{b_1}[1 + b_2(f_2 - f_1)], \quad \alpha_2 = \frac{1}{d} A_2\beta_2, \quad \alpha_3 = \frac{1}{d} A_3\beta_3,$$

$$\alpha_4 = \frac{1}{d} A_4\beta_4, \quad \alpha_5 = \frac{1}{d} A_5\beta_5, \quad \alpha_6 = \frac{1}{d} A_6\beta_6,$$

$$\alpha_7 = \alpha_8 = \ldots = 0;$$

$$k_1 = 0, \quad k_2 = (1 - A_2)\beta_2, \quad k_3 = (1 - A_3)\beta_3,$$

$$k_4 = (1 - A_4)\beta_4, \quad k_5 = (1 - A_5)\beta_5, \quad k_6 = (1 - A_6)\beta_6,$$

$$k_7 = k_8 = \ldots = 1;$$

$$h_1 = f_2 - f_1, \quad h_2 = f_3 - f_2, \quad h_3 = f_4 - f_3,$$

$$h_4 = f_5 - f_4, \quad h_5 = f_6 - f_6, \quad h_6 = 1 - f_6,$$

$$h_7 = h_8 = \ldots = 0;$$

$$g_1 = - a_3f_1,$$

$$g_2 = (a_4 - a_3)(f_2 - \beta_2) - a_{10}\alpha_2,$$

$$g_3 = (a_5 + a_4 - a_3)(f_3 - \beta_3) - (a_{10} + a_{11})\alpha_3,$$

$$g_4 = (a_5 + a_4 - a_3)(f_4 - \beta_4) - (a_{10} + a_{11})\alpha_4,$$

$$g_5 = (a_5 + a_4 - a_3)(f_5 - \beta_5) - (a_{10} + a_{11})\alpha_5,$$

$$g_6 = (a_5 + a_4 - a_3)(f_6 - \beta_6) - (a_{10} + a_{11})\alpha_6;$$

$$a_3 > \frac{2\{b_2[(1 - a_2)(1 + b_1\frac{A_5}{d}) + a_1 b_1] + a_1 b_1(1 + b_1\frac{A_5}{d})\}}{b_1(1 + b_1\frac{A_5}{d})},$$

$$\bar{a}_4 - a_3 > 0.$$

Since the long run equilibrium in case three is the same as that of the general model, we will not reiterate this part. As in section 2.4.3, case three can also generate short-run and intermediate run adjustment paths close to those generated by the general model in section 3.3. Therefore, we do not repeat this part, either.

However, as in section 2.4.3, the pace of adjustment for the whole economy before period 3 is faster than those of the general model because of the interplay of labor and trade contracts. But after period 3, the adjustment process for the economy depends entirely on the renewal speed of labor contracts. Generally, the renewals are smooth over time. Therefore, the whole economy after period 3 will adjust slowly and gradually to the new long-run equilibrium. During the process, the path of (e_t, p_t) may cross the 45^o line in the last couple of periods and at the same time, the trade balance may be worse than the initial level, before returning to the long-run level. The plausible paths for (e_t, p_t) and the trade balance depend on the pace of the reaction of the trade balance to changes in relative prices. If the pace is fast enough that a_4 exceeds a_3, the paths for (e_t, p_t) may be close to the one in Figure 3.5 while the paths for the trade balance is like the one in Figure 4.5. If a_3 exceeds a_4, however, the paths may be close to the ones in Figure 3.6 and in Figure 4.3 for (e_t, p_t) and the trade balance respectively.

Before closing this section, we would like to point out some shortcomings or features of these special cases. In case one, in which all parameters are fixed over time, the model provides short-run and long-run analyses but no intermediate-run analysis. It is this defect which is found in most rational expectations models in the literature. In case two, although the labor contracts of the Fischer (1977) type allow the parameter A_i's to change for a period, the one-period intermediate run is too short to demonstrate the entire adjustment process of the whole economy. In case three, the A_i's change over a longer intermediate run. Because of that, the adjustment paths generated by case three may be also most likely. The features of case three warrant attention.

4.4 Numerical Simulations

Since the model is large, sometimes we may lose information in our analytical explorations. The purpose of this section is to pick up the entire adjustment process and confirm what we have derived from the model by studying all the variables simultaneously.

The parameter values chosen are arbitrary. However, we try to choose values that appear to be reasonable. The assumed values of parameters are given at the top of each table.

In each table, period 1 depicts the short run, period 2 to 6 describes the intermediate run, and period 7 delineates the long run. In the long run, f, β and k are equal to one, that is, the exchange rate, price and the nominal wage change in the same proportion as the change in the money supply. Zero values for α, h and g imply that after six periods, output, the interest rate and the trade balance will return to their initial levels.

Let us turn to the short run and the intermediate run. Table 4.1 is used to describe the general case D of Chapter 3. In period 1 after the unanticipated increase in the money supply, price and wage are unchanged, the exchange rate depreciates but undershoots because of the dominant expected real interest rate effect on aggregate

Table 4.1. General case D.

Assumed values of parameters	$a_1=60$, $a_2=0.7$, $a_3=185$, $a_4=195$, $a_5=15$, $a_6=15$, $a_7=10$, $a_8=10$, $a_9=0$, $a_{10}=0.08$, $a_{11}=0.07$, $a_{12}=0.06$, $a_{13}=0.05$, $a_{14}=0.04$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_i = 1/6$, $i=1,...,6$.

Period	1	2	3	4	5	6	7
f	0.015	1.97	1.16	0.97	0.90	0.85	1
β	0	0.33	0.54	0.64	0.73	0.92	1
α	197	27	36	32	24	16	0
k	0	0.06	0.16	0.32	0.49	0.76	1
h	1.95	-0.81	-0.19	-0.07	-0.05	0.15	0
g	-2.8	14.24	10.1	6.48	2.26	-9	0

Table 4.2. General case E.

Assumed values of parameters	$a_1=20$, $a_2=0.7$, $a_3=81$, $a_4=91$, $a_5=15$, $a_6=15$, $a_7=15$, $a_8=10$, $a_9=0$, $a_{10}=0.08$, $a_{11}=0.07$, $a_{12}=0.06$, $a_{13}=0.05$, $a_{14}=0.04$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_i = 1/6$, $i=1,...,6$.

Period	1	2	3	4	5	6	7
f	-0.24	2.19	1.26	1.06	0.97	0.94	1
β	0	0.29	0.53	0.64	0.74	0.88	1
α	221	24	35	32	24	0.15	0
k	0	0.05	0.17	0.32	0.50	0.73	1
h	2.43	-0.93	-0.20	-0.09	-0.03	0.06	0
g	19.44	17.1	13	10.4	6.41	-0.6	0

Table 4.3. General case F.

Assumed values of parameters	$a_1=20$, $a_2=0.7$, $a_3=81$, $a_4=5$, $a_5=91$, $a_6=25$, $a_7=20$, $a_8=10$, $a_9=0$, $a_{10}=0.08$, $a_{11}=0.07$, $a_{12}=0.06$, $a_{13}=0.05$, $a_{14}=0.04$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_i = 1/6$, $i=1,...,6$.

Period	1	2	3	4	5	6	7
f	-0.24	0.30	1.71	1.06	0.96	0.93	1
β	0	0.92	0.40	0.63	0.75	0.88	1
α	128	76	27	32	25	15	0
k	0	0.14	1.16	0.32	0.50	0.72	1
h	0.54	1.41	-0.65	-0.11	-0.02	0.07	0
g	19.44	41.04	15.6	10.48	5.5	-1	0

Table 4.4. Special case one.

Assumed values of parameters	$a_1=20$, $a_2=0.7$, $a_3=6$, $a_4=0$, $a_5=0$, $a_6=0$, $a_7=0$, $a_8=0$, $a_9=0$, $a_{10}=0$, $a_{11}=0$, $a_{12}=0$, $a_{13}=0$, $a_{14}=0$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_1 = 1$, $c_2 = c_3 = c_4 = c_5 = c_6 = 0$.

Period	1	2	3	4	5	6	7
f	1.67	1	1	1	1	1	1
β	0	1	1	1	1	1	1
α	67	0	0	0	0	0	0
k	0	1	1	1	1	1	1
h	-0.67	0	0	0	0	0	0
g	10.02	0	0	0	0	0	0

Table 4.5. Special case two.

Assumed values of parameters	$a_1=20$, $a_2=0.7$, $a_3=81$, $\bar{a}_4=146$, $a_5=0$, $a_6=0$, $a_7=0$, $a_8=0$, $a_9=0$, $a_{10}=0.3$, $a_{11}=0$, $a_{12}=0$, $a_{13}=0$, $a_{14}=0$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_1 = c_2 = 1/2$, $c_3 = \ldots = c_6 = 0$.

Period	1	2	3	4	5	6	7
f	-0.21	0.87	1	1	1	1	1
β	0	0.70	1	1	1	1	1
α	154	35	0	0	0	0	0
k	0	0.35	1	1	1	1	1
h	1.08	0.13	0	0	0	0	0
g	17.01	0.55	0	0	0	0	0

Table 4.6. Special case three.

Assumed values of parameters	$a_1=20$, $a_2=0.7$, $a_3=81$, $a_4=101$, $a_5=45$, $a_6=0$, $a_7=0$, $a_8=0$, $a_9=0$, $a_{10}=0.15$, $a_{11}=0.15$, $a_{12}=0$, $a_{13}=0$, $a_{14}=0$, $a_{15}=0$, $b_1=0.01$, $b_2=0.5$, $d=0.01$, $c_i = 1/6$, $i=1,\ldots,6$.

Period	1	2	3	4	5	6	7
f	-0.24	1.51	0.947	0.949	0.952	0.943	1
β	0	0.39	0.60	0.67	0.75	0.88	1
α	195	32	40	34	25	15	0
k	0	0.07	0.20	0.34	0.50	0.71	1
h	1.75	-0.56	0.012	0.013	-0.01	0.05	0
g	19.44	17.6	10.75	8.00	5.5	-0.6	0

demand and the stabilizing effect of the J-curve in the rational expectational model.

Due to the expected overshooting of the exchange rate in period 2, the interest rate goes up and dampens the money demand. But since the price level is unchanged, an increase in the nominal money stock results in an increase in the real money supply. To maintain the money market equilibrium, output expands very quickly in period 1. The trade balance worsens owing to the J-curve effects. In period 2, since the relative price effect on the trade balance outweighs the J-curve effects, the exchange rate in period 3 is expected to appreciate. Therefore, the interest rate falls below the initial level and capital flows out, and the exchange rate overshoots. Price goes up and output decreases but remains above the initial level. The nominal wage increases by one-sixth of the price hike because one-sixth of the labor contracts have been renewed at higher nominal wage rates which maintain the constancy of the real wage. The trade balance jumps to the highest surplus due to the overshooting and low price inflation relative to that in the remaining periods.

In period 3, traders with prior expectations at period t-1 and t-2 could adjust their exports and imports, and the relative price effect increases to $a_4 + a_5 - a_3$. One-sixth of the labor contracts have been renewed and another sixth will renew in the next period. The effect is to make the exchange rate appreciate further, and the interest rate goes up but remains below the initial level. The trade balance begins to decline. The same adjustment process goes on in the remaining periods, then approaches the long-run equilibrium. However, in period 6, owing to $f_6 < \beta_6$, the path of (e_t, p_t) crosses the 45° line, the trade balance dips below the initial level and the interest rate increases again because the exchange rate is expected to depreciate back to the long-run level and another sixth of the labor contracts are expected to be renewed in the next period.

For the other tables, we shall not repeat the adjustment process which is similar. Instead, we shall focus on their distinctive features.

The distinction of Table 4.2 is the contemporaneous countershooting of the exchange rate, which is due to J-curve effects and the small magnitude of the expected real interest rate effect on aggregate demand. The countershooting reverses the J-curve effects on the trade balance and the trade balance surprisingly improves in the short run. The positive effects on output and the interest rate are larger because of the countershooting. Since the assumed values of parameters in Table 4.2 are closer to the real world than those in Table 4.1, the general case E in Table 4.2 may be the most probable one generated from the rational expectations model under flexible exchange rates. When rational expectations models consider J-curve effects, the adjustment process of the exchange rate may be the following: countershooting in the short run, followed by overshooting and then undershooting in the intermediate run. The trade balance not only improves but also reaches its highest surplus in the first period, then declines gradually to the long-run level, but becomes worse than the initial level in period 6.

Table 4.3 considers the case of slow adjustment of exports and imports. The distinctive feature is that significant J-curve effects still dominate the relative price effect on the trade balance in period 2, that is, $a_4 - a_3 < 0$. The exchange rate countershoots in period 1, undershoots in period 2, overshoots for the next two periods and then undershoots for the last two periods. In period 2, price jumps so high that monotonic movement toward the long-run level becomes impossible. The interest rate in period 2 increases because of the expected overshooting in period 3. The reversal of J-curve effects on the trade balance remains in period 2 because the price increase exceeds the undershooting of the exchange rate.

Table 4.4 is used to illustrate the Dornbusch case. Since the J-curve effects are not considered here, the restriction on a_3 is $a_3 > 0$. Contemporaneous overshooting of the exchange rate can occur if the value of a_1 is reasonably small. But the interest rate falls in the short run because the exchange rate is expected to appreciate in the next period, that is, in the long run. Although the short-run and long-run results can be generated, this special case overlooks the intermediate run, which can be regarded as a major part of dynamic economic theory.

In Tables 4.5 and 4.6, the given values of all fixed parameters are the same as those in Table 4.2. This allows us to compare them to Table 4.2. Table 4.5 is for special case two. Because of large $\bar{a}_4$ and $\bar{a}_{10}$, in period 2, the exchange rate generally undershoots instead of overshooting, and price inflation soars. The trade balance is highest in the first period, not in the second period. The problem with Table 4.5 is that the intermediate run is too short to describe the entire adjustment process properly.

Table 4.6 is for special case three. Since a_4 exceeds a_3, the trade balance adjusts relatively fast and J-curve effects are dominated in period 2. As predicted in section 4.3.3, Table 4.6 generates the adjustment path similar to those in Table 4.2 or in general model. However, the pace of adjustment is faster than those in Table 4.2, before period 3, but is slower after the period.

4.5 Conclusions

Let us summarize the main results derived from the model after an unanticipated increase in the money supply under flexible exchange rates.

In the short run, a significant J-curve effect on the trade balance can cause a contemporaneous countershooting or undershooting of the exchange rate. Output is very expansionary because of the contemporaneous countershooting and the expected undershooting or overshooting of the exchange rate. The trade balance may move to its greatest surplus position owing to the exchange-rate countershooting or J-curve effects reversal. The interest rate may increase.

In the intermediate run, an unanticipated increase in the money supply could generate a more complex time path for the exchange rate, that is, overshooting and undershooting. The trade balance, since it may reach its highest position in period 1, may decrease gradually until it falls below the initial level, then increase gradually to the long-run level. The interest rate may first decrease and then increase for a while owing to the expected paths of the exchange rate. However, price, output and wages adjust relatively smoothly during the intermediate run.

In the long run, an unanticipated increase in the money supply increases the exchange rate, price and wage proportionately. But the trade balance, the interest rate and output remain unchanged.

Notes

[1] See note 1 in Chapter 3.

[2] Special case two is the same as that of Ueda (1983) except that he considered the temporary monetary disturbance. A temporary disturbance affects the endogenous variable only in the first period. The effects are more or less the same as the initial effects of a permanent disturbance which is considered in this chapter. Unless the chapter will go on to discuss the problems relating to the effects of the confusion between the permanent and temporary disturbance, exclusion of the temporary disturbance will not change the conclusions made in this chapter.

[3] Ueda (1983) did not impose the restriction on a_3 for a unique solution of the rational expectations model. Hence, he indicated wrongly that $f_1 > f_2$. See Ueda (1983), p. 33.

CHAPTER 5
SUMMARY AND CONCLUSIONS

The literature of trade balance dynamics has focused on the short-run and long-run analyses and has ignored the intermediate run. In this study, two rational expectations models incorporating overlapping trade contracts and labor contracts are developed. They allow the relative price and income effect on the trade balance and the renewal rate of labor contracts to increase over time, thus making an intermediate-run analysis possible. The main results derived from the two models are summarized as follows.

In the long run, there is symmetry between the regimes of fixed and flexible exchange rates. Under fixed exchange rates, the exchange rate is exogenous and the supply of money endogenous. Under flexible exchange rates, the supply of money is exogenous and the exchange rate endogenous. A devaluation under fixed exchange rates increases the supply of money, price and wage proportionately in the long run. Under flexible exchange rates, an increase in the money stock increases the exchange rate, prices and wages proportionately in the long run. However, the trade balance, the interest rate and output remain unchanged in the long run under both regimes.

In the short run, output contracts under fixed exchange rates if the J-curve effects are dominant. But, due to the contemporaneous countershooting and the expected overshooting or undershooting of the exchange rate, output is expanded dramatically under flexible exchange rates. Under fixed exchange rates, an unexpected devaluation creates J-curve effects on the trade balance. Under flexible exchange rates, an unanticipated increase in the money supply could improve the contemporaneous trade balance because of exchange rate countershooting. The interest rate is unchanged under fixed exchange rates, but it may increase under flexible exchange rates.

In the intermediate run, an unexpected devaluation under fixed exchange rates increases the money supply monotonically. But an unanticipated increase in the money supply under flexible exchange rates could generate a more complex time path for the exchange rate, that is, overshooting and undershooting. For the trade balance, since it may reach the highest position in period one under flexible exchange rates, it may decrease gradually below the initial level before returning to its long-run level. Under fixed exchange rates, the trade balance first increases gradually then decreases monotonically to

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the long-run level. The interest rate remains unchanged over the intermediate run under fixed exchange rates, but it may decrease first and then increase for a while under flexible exchange rates owing to the expected paths of the exchange rate. Under both regime, however, price, output and wage adjust relatively smoothly.

In deriving the above results we have made strong assumptions which may limit their applicability. Most important of all, we assume a small country and perfect capital mobility and substitutability. In addition, only the effects of permanent disturbances to the exchange rate and money supply were analyzed. When these assumptions are relaxed or other forms of disturbances are considered, for instance, the possible confusion of permanent and transitory disturbances, the results would probably be modified. Nonetheless, the present models seem sufficiently flexible to allow for useful extensions in future research.

APPENDIX A
SOLVING THE MODEL IN SECTION 2.2

The model of Chapter 2 is as follows:

$$y_t = a_0 - a_1(i_t - {}_tp_{t+1} + p_t) + a_2y_t - a_3(e_t - p_t)$$

$$+ \sum_{i=1}^{6} a_{3+i}({}_{t-i}e_t - {}_{t-i}p_t) - \sum_{i=1}^{6} a_{9+i}\ {}_{t-i}y_t \qquad (2.5)$$

$$m_t - p_t = b_0 + b_1y_t - b_2i_t \qquad (2.7)$$

$$i_t = i^* + {}_te_{t+1} - e_t \qquad (2.8)$$

$$e_t = \sum_{i=0}^{\infty} v_{t-i} \qquad (2.9)$$

$$p_t = {}_{t-1}w_t + d({}_{t-1}y_t - \bar{y}) \qquad (2.10)$$

$$w_t = \sum_{i=1}^{6} c_i\ {}_{t-i}p_t, \quad \sum_{i=1}^{6} c_i = 1, \quad c_i > 0 \qquad (2.12)$$

Since equations (2.8) and (2.12) are linearly dependent, they need not be considered now. In order to get the reduced-form solution given in equations (2.13) - (2.18), we have to hypothesize the distributions of output, price and the money supply with undetermined coefficients on the basis of the exchange rate disturbances which occurred up to and including period t, that is,

$$\begin{bmatrix} y_t \\ p_t \\ m_t \end{bmatrix} = \begin{bmatrix} \pi_{11} & \pi_{12} & \pi_{13} & \pi_{14} & \cdots \\ \pi_{21} & \pi_{22} & \pi_{23} & \pi_{24} & \cdots \\ \pi_{31} & \pi_{32} & \pi_{33} & \pi_{34} & \cdots \end{bmatrix} \begin{bmatrix} 1 \\ v_t \\ v_{t-1} \\ v_{t-2} \\ \vdots \end{bmatrix} \qquad (A.1)$$

where the π_{ij}'s are undetermined reduced form coefficients. Using equation (A.1), we get ${}_{t-1}y_t$, ${}_{t-1}p_t$, ${}_{t}p_{t+1}$, ${}_{t-2}p_t$, ${}_{t-3}p_t$, ${}_{t-4}p_t$, ${}_{t-5}p_t$ and ${}_{t-6}p_t$ in terms of the π_{ij}'s.

$$
\begin{aligned}
{}_{t-1}y_t = \pi_{11} &+ \pi_{13}v_{t-1} + \pi_{14}v_{t-2} + \pi_{15}v_{t-3} + \pi_{16}v_{t-4} \\
&+ \pi_{17}v_{t-5} + \pi_{18}v_{t-6} + \cdots
\end{aligned}
$$

$$
\begin{aligned}
{}_{t-1}p_t = \pi_{21} &+ \pi_{23}v_{t-1} + \pi_{24}v_{t-2} + \pi_{25}v_{t-3} + \pi_{26}v_{t-4} \\
&+ \pi_{27}v_{t-5} + \pi_{28}v_{t-6} + \cdots
\end{aligned}
$$

$$
\begin{aligned}
{}_{t}p_{t+1} = \pi_{21} &+ \pi_{23}v_{t} + \pi_{24}v_{t-1} + \pi_{25}v_{t-2} + \pi_{26}v_{t-3} \\
&+ \pi_{27}v_{t-4} + \pi_{28}v_{t-5} + \pi_{29}v_{t-6} + \cdots
\end{aligned}
$$

$${}_{t-2}p_t = \pi_{21} + \pi_{24}v_{t-2} + \pi_{25}v_{t-3} + \pi_{26}v_{t-4} + \pi_{27}v_{t-5} + \pi_{28}v_{t-6} + \cdots$$

$${}_{t-3}p_t = \pi_{21} + \pi_{25}v_{t-3} + \pi_{26}v_{t-4} + \pi_{27}v_{t-5} + \pi_{28}v_{t-6} + \cdots$$

$${}_{t-4}p_t = \pi_{21} + \pi_{26}v_{t-4} + \pi_{27}v_{t-5} + \pi_{28}v_{t-6} + \cdots$$

$${}_{t-5}p_t = \pi_{21} + \pi_{27}v_{t-5} + \pi_{28}v_{t-6} + \cdots$$

$${}_{t-6}p_t = \pi_{21} + \pi_{28}v_{t-6} + \cdots$$

Substituting them into the fundamental equations (2.5), (2.7) and (2.10), we get equations (2.5'), (2.7') and (2.10').

$$d[\pi_{11} + \pi_{13}v_{t-1} + \pi_{14}v_{t-2} + \pi_{15}v_{t-3} + \pi_{16}v_{t-4} + \pi_{17}v_{t-5} + \pi_{18}v_{t-6} + \pi_{19}v_{t-7} + \cdots]$$

$$= d\bar{y} + (c_1 + c_2 + c_3 + c_4 + c_5 + c_6)\pi_{22}v_t + (c_2 + c_3 + c_4 + c_5 + c_6)\pi_{23}v_{t-1} + (c_3 + c_4 + c_5 + c_6)\pi_{24}v_{t-2}$$

$$+ (c_4 + c_5 + c_6)\pi_{25}v_{t-3} + (c_5 + c_6)\pi_{26}v_{t-4} + c_6\pi_{27}v_{t-5}$$

(2.10')

$$(\pi_{31} - \pi_{21}) + (\pi_{32} - \pi_{22})v_t + (\pi_{33} - \pi_{23})v_{t-1}$$

$$+ (\pi_{34} - \pi_{24})v_{t-2} + (\pi_{35} - \pi_{25})v_{t-3} + (\pi_{36} - \pi_{26})v_{t-6}$$

$$+ (\pi_{37} - \pi_{27})v_{t-5} + (\pi_{38} - \pi_{28})v_{t-6} + \cdots$$

$$= b_0 + b_1\pi_{11} - b_2 i^* + b_1\pi_{12}v_t + b_1\pi_{13}v_{t-1} + b_1\pi_{14}v_{t-2}$$

$$+ b_1\pi_{15}v_{t-3} + b_1\pi_{16}v_{t-4} + b_1\pi_{17}v_{t-5} + b_1\pi_{18}v_{t-6} + \cdots$$

(2.7')

$$(1 - a_2)(\pi_{11} + \pi_{12}v_t + \pi_{13}v_{t-1} + \pi_{14}v_{t-2} + \pi_{15}v_{t-3} + \pi_{16}v_{t-4}$$

$$+ \pi_{17}v_{t-5} + \pi_{18}v_{t-6} + \cdots)$$

$$= a_0 - a_1 i^* + (a_9 + a_8 + a_7 + a_6 + a_5 + a_4 - a_3)\pi_{21}$$

$$+ [-a_1(\pi_{22} - \pi_{23}) - a_3(1 - \pi_{22})]v_t$$

$$+ [-a_1(\pi_{23} - \pi_{24}) - a_3(1 - \pi_{23}) + a_4(1 - \pi_{23}) - a_{10}\pi_{13}]v_{t-1}$$

$$
\begin{aligned}
&+ [-a_1(\pi_{24} - \pi_{25}) - a_3(1 - \pi_{24}) + a_4(1 - \pi_{24}) + a_5(1 - \pi_{24}) \\
&- (a_{10} + a_{11})\pi_{14}]v_{t-2} \\
&+ [-a_1(\pi_{25} - \pi_{26}) - a_3(1 - \pi_{25}) + a_4(1 - \pi_{25}) + a_5(1 - \pi_{25}) \\
&+ a_6(1 - \pi_{25}) - (a_{10} + a_{11} + a_{12})\pi_{15}]v_{t-3} \\
&+ [-a_1(\pi_{26} - \pi_{27}) + (a_7 + a_6 + a_5 + a_4 - a_3)(1 - \pi_{26}) \\
&- (a_{10} + a_{11} + a_{12} + a_{13})\pi_{16}]v_{t-4} \\
&+ [-a_1(\pi_{27} - \pi_{28}) + (a_8 + a_7 + a_6 + a_5 + a_4 - a_3)(1 - \pi_{27}) \\
&- (a_{10} + a_{11} + a_{12} + a_{13} + a_{14})\pi_{17}]v_{t-5} \\
&+ [-a_1(\pi_{28} - \pi_{29}) + (a_9 + a_8 + a_7 + a_6 + a_5 + a_4 - a_3) \\
&(1 - \pi_{28}) - (a_{10} + a_{11} + a_{12} + a_{13} + a_{14} + a_{15})\pi_{18}]v_{t-6}.
\end{aligned}
\tag{2.5'}
$$

Equating the coefficients of same term v_{t-i} on both sides of equations (2.5'), (2.7') and (2.10'), we obtain the following:

From equation (2.10'), we get (A.2).

$\pi_{11} = \bar{y}$ $\quad 0 = \pi_{22}$ $\quad \pi_{13} = \frac{1}{d} A_2\pi_{23}$

$\pi_{14} = \frac{1}{d} A_3\pi_{24}$ $\quad \pi_{15} = \frac{1}{d} A_4\pi_{25}$ $\quad \pi_{16} = \frac{1}{d} A_5\pi_{26}$

$\pi_{17} = \frac{1}{d} A_6\pi_{27}$ $\quad \pi_{18} = 0$ $\quad \pi_{19} = 0$

.... (A.2)

where $A_2 = c_2 + c_3 + c_4 + c_5 + c_6$

$A_3 = c_3 + c_4 + c_5 + c_6$

$A_4 = c_4 + c_5 + c_6$

$A_5 = c_5 + c_6$

$A_6 = c_6$

From equation (2.7'), we have (A.3).

$\pi_{31} = \pi_{21} + b_0 + b_1c_0 - b_2i^*$ $\quad \pi_{32} = b_1\pi_{12}$

$\pi_{33} = \pi_{23} + b_1\pi_{13}$ $\quad \pi_{34} = \pi_{24} + b_1\pi_{14}$

$\pi_{35} = \pi_{25} + b_1\pi_{15}$ $\quad$ $\pi_{36} = \pi_{26} + b_1\pi_{16}$

$\pi_{37} = \pi_{27} + b_1\pi_{17}$ $\quad$ $\pi_{38} = \pi_{28}$

$\pi_{39} = \pi_{29}$ $\quad$ ...... (A.3)

From equation (2.5'), we obtain equations (A.4) - (A.10).

For term v_{t-6}, $(1-a_2)\pi_{18} =$

$$[-a_1(\pi_{28}-\pi_{29}) + (a_9+a_8+a_7+a_6+a_5+a_4-a_3)(1-\pi_{28})$$

$$- (a_{10} + a_{11} + a_{12} + a_{13} + a_{14} + a_{15})\pi_{18}] \qquad (A.4)$$

For term v_{t-5}, $(1-a_2)\pi_{17} =$

$$[-a_1(\pi_{27}-\pi_{28}) + (a_8+a_7+a_6+a_5+a_4-a_3)(1-\pi_{27})$$

$$- (a_{10} + a_{11} + a_{12} + a_{13} + a_{14})\pi_{17}] \qquad (A.5)$$

For term v_{t-4}, $(1-a_2)\pi_{16} =$

$$[-a_1(\pi_{26}-\pi_{27}) + (a_7+a_6+a_5+a_4-a_3)(1-\pi_{26})$$

$$- (a_{10} + a_{11} + a_{12} + a_{13})\pi_{16}] \qquad (A.6)$$

For term v_{t-3}, $(1-a_2)\pi_{15}$ =

$$[-a_1(\pi_{25}-\pi_{26}) + (a_6+a_5+a_4-a_3)(1-\pi_{25})$$

$$- (a_{10} + a_{11} + a_{12})\pi_{15}] \qquad (A.7)$$

For term v_{t-2}, $(1-a_2)\pi_{14}$ =

$$[-a_1(\pi_{24}-\pi_{25}) + (a_5+a_4-a_3)(1-\pi_{24}) - (a_{10} + a_{11})\pi_{14}]$$

(A.8)

For term v_{t-1}, $(1-a_2)\pi_{13}$ =

$$[-a_1(\pi_{23}-\pi_{24}) + (a_4-a_3)(1-\pi_{23}) - a_{10}\pi_{13}] \qquad (A.9)$$

For term v_t, $(1-a_2)\pi_{12} = [-a_1(\pi_{22}-\pi_{23}) - a_3(1-\pi_{22})]$ (A.10)

Using the solution in (A.2), we can reduce equations (A.4) - (A.9) to first-order difference equations. Let us solve equation (A.4) first. Since $\pi_{18} = 0$, equation (A.4) becomes

$$-a_1\pi_{29}+(a_9+a_8+a_7+a_6+a_5+a_4-a_3+a_1)\pi_{28} = (a_9+a_8+a_7+a_6+a_5+a_4-a_3)$$

This is the linear first-order difference equation. Its solution is as follows:

$$\pi_{28} = A\left(\frac{a_1 + a_9 + a_8 + a_7 + a_6 + a_5 + a_4 - a_3}{a_1}\right)^t + 1$$

$$\pi_{28} = A(\lambda)* + 1$$

$$\lambda = 1 + \frac{a_9 + a_8 + a_7 + a_6 + a_5 + a_4 - a_3}{a_1} > 1$$

$$\text{if } a_9 + a_8 + a_7 + a_6 + a_5 + a_4 > a_3$$

$\lambda > 1$ implies $A = 0$; hence $\pi_{28} = 1$ (unique solution of π_{28})

Similarly, $\pi_{29} = 1$, $\pi_{2,10} = 1$, ... Next, let us solve equation (A.5). Because $\pi_{17} = \frac{1}{d} A_6 \pi_{27}$, equation (A.5) becomes

$$\pi_{28} + \left[\frac{\frac{1}{d}(1-a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14})A_6+(a_8+a_7+a_6+a_5+a_4-a_3+a_1)}{-a_1}\right]\pi_{27}$$

$$= \frac{(a_8+a_7+a_6+a_5+a_4-a_3)}{-a_1}$$

π_{27} =

$$A\left\{1+\frac{[\frac{1}{d}(1-a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14})A_6+a_8+a_7+a_6+a_5+a_4-a_3]}{a_1}\right\}^t$$

$$+\frac{a_8+a_7+a_6+a_5+a_4-a_3}{\frac{1}{d}(1-a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14})A_6+(a_8+a_7+a_6+a_5+a_4-a_3)}$$

In order to get a unique solution for π_{27}, we set the characteristic root λ greater than unity, that is,

$$\lambda = 1 + \frac{\frac{1}{d}(1-a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14})A_6+a_8+a_7+a_6+a_5+a_4-a_3}{a_1} > 1$$

If $\frac{1}{d}(1-a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14})A_6+a_8+a_7+a_6+a_5+a_4-a_3 > 0.$

$\lambda > 1$ implies $A = 0$, and

$$\pi_{27} = \frac{a_8+a_7+a_6+a_5+a_4-a_3}{\frac{1}{d}(1-a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14})A_6+(a_8+a_7+a_6+a_5+a_4-a_3)}$$

This is the unique solution of π_{27}, and the restriction for the solution is that its denominator be positive. Similarly, we can get the unique solution for π_{26}, π_{25}, π_{24} and π_{23} from equations (A.6), (A.7), (A.8) and (A.9), that is,

$$\pi_{26} = \frac{(a_7 + a_6 + a_5 + a_4 - a_3)}{\frac{1}{d}(1 - a_2+a_{10}+a_{11}+a_{12}+a_{13})A_5 + (a_7+a_6+a_5+a_4-a_3)}$$

$$\pi_{25} = \frac{(a_6 + a_5 + a_4 - a_3)}{\frac{1}{d}(1 - a_2 + a_{10} + a_{11} + a_{12})A_4 + (a_6 + a_5 + a_4 - a_3)}$$

$$\pi_{24} = \frac{(a_5 + a_4 - a_3)}{\frac{1}{d}(1 - a_2 + a_{10} + a_{11})A_3 + (a_5 + a_4 - a_3)}$$

$$\pi_{23} = \frac{(a_4 - a_3)}{\frac{1}{d}(1 - a_2 + a_{10})A_2 + (a_4 - a_3)}$$

All denominators should be positive to ensure getting a unique solution. From equation (A.10), we get

$$\pi_{12} = \frac{a_1\pi_{23} - a_3}{1 - a_2}$$

After getting the unique solution from equations (A.6) - (A.10), and substituting the solution back to (A.2) and (A.3), we get the unique solution for π_{11}, π_{12}, π_{13}, ..., π_{31}, π_{32}, ...

If we set $\pi_{11} = y_0$, $\pi_{12} = \alpha_1$, $\pi_{13} = \alpha_2$, $\pi_{14} = \alpha_3$, $\pi_{15} = \alpha_4$, $\pi_{16} = \alpha_5$, $\pi_{17} = \alpha_6$, $\pi_{21} = p_0$, $\pi_{22} = \beta_1 = 0$, $\pi_{23} = \beta_2$, $\pi_{24} = \beta_3$, $\pi_{25} = \beta_4$, $\pi_{26} = \beta_5$, $\pi_{27} = \beta_6$, $\pi_{28} = \beta_7 = 1$ ..., $\pi_{31} = m_0$, $\pi_{32} = \gamma_1$, $\pi_{33} = \gamma_2$, $\pi_{34} = \gamma_3$, $\pi_{35} = \gamma_4$, $\pi_{36} = \gamma_5$, $\pi_{37} = \gamma_6$, $\pi_{38} = \gamma_7 = 1$ ..., then we get the reduced-form solutions (2.13), (2.14) and (2.15) for y_t, p_t and m_t. Substituting equations (2.9), (2.13), (2.14) or (2.15) into equations (2.12), (2.8) and (2.5), we get the reduced-form solutions for w_t, i_t, T_t, that is, equations (2.16), (2.17) and (2.18). Then we obtain the general solution in section 2.3.

APPENDIX B
A CONTEMPORANEOUS COUNTERSHOOTING OR UNDERSHOOTING OF THE EXCHANGE RATE CAUSED BY J-CURVE EFFECTS

This appendix proves that J-curve effects on the trade balance may cause a contemporaneous countershooting or undershooting of the exchange rate following an unanticipated monetary disturbance.

Proof:

In order to obtain a restriction for a_3, we should derive the characteristic equation connecting to a_3. To get the equation, we have to hypothesize the distributions of output, price and the exchange rate with undetermined coefficients on the basis of the monetary disturbances which occurred up to and including period t. That is,

$$\begin{bmatrix} y_t \\ p_t \\ e_t \end{bmatrix} = \begin{bmatrix} \pi_{11} & \pi_{12} & \pi_{13} & \pi_{14} & \pi_{15} & \pi_{16} & \pi_{17} & \cdots \\ \pi_{21} & \pi_{22} & \pi_{23} & \pi_{24} & \pi_{25} & \pi_{26} & \pi_{27} & \cdots \\ \pi_{31} & \pi_{32} & \pi_{33} & \pi_{34} & \pi_{35} & \pi_{36} & \pi_{37} & \cdots \end{bmatrix} \begin{bmatrix} 1 \\ u_t \\ u_{t-1} \\ u_{t-2} \\ u_{t-3} \\ u_{t-4} \\ u_{t-5} \\ \vdots \end{bmatrix} \tag{B.1}$$

where π_{ij}'s are undetermined reduced form coefficients. Substituting them into fundamental equations (3.1), (3.2) and (3.5), equating coefficients of u_t in equation (3.1) and reducing π_{12}, π_{22}, π_{23} to π_{32}, π_{33}, π_{34}, we can have a second order expectational difference equation (B.2).

$$\frac{-a_1 b_2}{1 + b_1 \frac{A_2}{d}} \pi_{34} + \left[(1 - a_2) \frac{b_2}{b_1} + \frac{a_1 b_2}{1 + b_1 \frac{A_2}{d}} + a_1\right] \pi_{33} + \left[-(1 - a_2) \frac{b_2}{b_1} - a_1 + a_3\right] \pi_{32} = -(1 - a_2) \frac{1}{b_1} + \frac{a_1}{1 + b_1 \frac{A_2}{d}} \tag{B.2}$$

The characteristic equation is (B.3).

$$(a_1 b_1 b_2)\lambda^2 - \left\{b_2\left[(1-a_2)(1+b_1\frac{A_2}{d})+a_1 b_1\right]+a_1 b_1 (1+b_1\frac{A_2}{d})\right\}\lambda + \left[b_2(1-a_2)+a_1 b_1-a_3 b_1\right](1+b_1\frac{A_2}{d}) = 0 \tag{B.3}$$

The two characteristic roots λ_1 and λ_2 are as follows:

$$\lambda_1, \lambda_2 = \frac{(y + w + z) \pm \left[(y + w + z)^2 - 4w(y + z + k)\right]^{1/2}}{2w} \tag{B.4}$$

where $w = a_1 b_1 b_2$, $y = b_2(1 - a_2)(1 + b_1 \frac{A_2}{d})$

$$z = a_1 b_1 (1 + b_1 \frac{A_2}{d}), \quad k = -a_3 b_1 (1 + b_1 \frac{A_2}{d})$$

To ensure that the rational expectations solution is unique, we impose the condition that $|\lambda_i| > 1$, $i=1,2$.

When the J-curve effects on the trade balance occur, the value of k is negative. If $\lambda_1 > 1$, that is,

$$\frac{(y + z + w) + [(y + w + z)^2 - 4w(y + z + k)]^{1/2}}{2w} > 1$$

Since $k < 0$, hence,

$$[(w - y - z)^2 - 4wk]^{1/2} > w - y - z$$

$$(w - y - z)^2 - 4wk > (w - y - z)^2$$

$$-4wk > 0$$

$$k < 0$$

The value of $k < 0$ implies $a_3 > 0$. So we get (B.5).

$$a_3 > 0 \qquad \text{(B.5)}$$

We assume $\lambda_2 > 1$ too, then

$$\frac{(y + w + z) - [(y + w + z)^2 - 4w(y + z + k)]^{1/2}}{2w} > 1$$

$$(y - w + z) > [(y - w + z)^2 - 4wk]^{1/2}$$

The inequality is invalid since k is negative. Because of the assumed negative value for k, it is invalid to suppose $\lambda_2 > 1$. Therefore, we must assume $\lambda_2 < -1$, that is,

$$\frac{(y + w + z) - [(y + w + z)^2 - 4w(y + z + k)]^{1/2}}{2w} < -1$$

$$(y + 3w + z) < [(y + z - w) - 4\ wk]^{1/2}$$

$$(y + 3w + z)^2 < (y + z - w)^2 - 4wk$$

$$k < -2(y + w + z)$$

Then, we can get (B.6).

$$a_3 > \frac{2\{b_2[(1-a_2)(1+b_1\frac{A_2}{d})+a_1b_1]+a_1b_1(1+b_1\frac{A_2}{d})\}}{b_1(1+b_1\frac{A_2}{d})} \qquad (B.6)$$

Since the right term of (B.6) is positive, and (B.6) is more restrictive than (B.5), the restriction on a_3 is (B.6) when the model considers J-curve effects.

When the model does not consider J-curve effects on the trade balance, the negative a_3 has changed to positive a_3, that is, $-a_3$ becomes a_3. That implies the value of k will change from negative to positive, that is, $k > 0$.

Now, if λ_1 is assumed to exceed one, that implies

$$\frac{(y + w + z) + [(y + w + z)^2 - 4w(y + z + k)]^{1/2}}{2w} > 1$$

$$[(y - w + z)^2 - 4wk]^{1/2} > w - y - z$$

Because $k > 0$, the inequality sign will be reversed when both sides are squared, that is,

$$(y - w + z)^2 - 4wk < (w - y - z)^2$$

$$-4wk < 0$$

$$k > 0$$

The value of $k > 0$ implies (B.7).

$$a_3 > 0 \tag{B.7}$$

For the value of λ_2, let us suppose $\lambda_2 < -1$ is possible. That is,

$$\frac{y + w + z - [(y + w + z)^2 - 4w(y + z + k)]^{1/2}}{2w} < -1$$

$$(y + 3w + z) < [(y - w + z)^2 - 4k]^{1/2} \qquad (B.8)$$

Since $k > 0$ and $(y + 3w + z)^2 > (y - w + z)^2$, (B.8) is invalid. Therefore, the inequality (B.8) is proved impossible and we should assume $\lambda_2 > 1$ for having a unique solution for the expectational difference equation.

If $\lambda_2 > 1$, too, we have

$$\frac{(y + w + z) - [(y + w + z)^2 - 4w(y + z + k)]^{1/2}}{2w} > 1$$

$$(y - w + z)^2 > (y - w + z)^2 - 4wk$$

$$0 > -4wk$$

$$k > 0$$

Then get (B.9)

$$a_3 > 0 \qquad (B.9)$$

Equations (B.8) and (B.9) imply that the restriction on a_3 is $a_3 > 0$ when the model does not consider the J-curve effects on the trade balance. From (3.13), $a_3 > 0$ implies that a contemporaneous overshooting of the exchange rate is possible. But, when the J-curve effects are considered, the restriction on a_3 is (B.6). Using (B.6), we can prove $|f_1| < 1$. That is, the J-curve effects on the trade balance can cause a contemporaneous countershooting or undershooting of the exchange rate after an unanticipated increase in the money supply.

The value of a_1 determines whether there is countershooting or undershooting. Generally, the value of $a_1 b_1$ is relatively smaller than the term $(1 - a_2)(1 + b_1 \frac{A_2}{d})$ in f_1, hence a countershooting could be likely if a rational expectations model considers J-curve effect on the trade balance under flexible exchange rates.

An explanation of the phenomenon is that a significant J-curve effect brings about expectations that an undershooting or overshooting would happen in the next period. Accordingly, the current interest rate increases and the exchange rate appreciates contemporaneously, that is, it countershoots.

APPENDIX C
SOLVING THE MODEL IN SECTION 3.2

The model of Chapter 3 is as follows:

$$y_t = a_0 - a_1(i_t - {}_tp_{t+1} + p_t) + a_2y_t - a_3(e_t - p_t)$$

$$+ \sum_{i=1}^{6} a_{3+i}({}_{t-i}e_t - {}_{t-i}p_t) - \sum_{i=1}^{6} a_{9+i}\ {}_{t-i}y_t \qquad (3.1)$$

$$m_t - p_t = b_0 + b_1y_t - b_2i_t \qquad (3.2)$$

$$i_t = i^* + {}_te_{t+1} - e_t \qquad (3.3)$$

$$m_t = \sum_{i=0}^{\infty} u_{t-i} \qquad (3.4)$$

$$p_t = {}_{t-1}w_t + d({}_{t-1}y_t - \bar{y}) \qquad (3.5)$$

$$w_t = \sum_{i=1}^{6} c_i\ {}_{t-i}p_t, \quad \sum_{i=1}^{6} c_i = 1, \quad c_i > 0 \qquad (3.6)$$

Since equations (3.3) and (3.6) are linearly dependent, they need not be considered now. In order to get the reduced-form solution given in equations (3.7) - (3.11) of the text, we have to hypothesize the distribution of output, price and the exchange rate with undetermined coefficients on the basis of the money supply disturbances which occurred up to and including period t. That is,

$$\begin{bmatrix} y_t \\ p_t \\ e_t \end{bmatrix} = \begin{bmatrix} \pi_{11} & \pi_{12} & \pi_{13} & \pi_{14} & \cdots \\ \pi_{21} & \pi_{22} & \pi_{23} & \pi_{24} & \cdots \\ \pi_{31} & \pi_{32} & \pi_{33} & \pi_{34} & \cdots \end{bmatrix} \begin{bmatrix} 1 \\ u_t \\ u_{t-1} \\ u_{t-2} \\ u_{t-3} \\ \vdots \end{bmatrix} \qquad (C.1)$$

where π_{ij}'s are undetermined reduced-form coefficients. Using (C.1), we get

$${}_{t-1}y_t = \pi_{11} + \pi_{13}u_{t-1} + \pi_{14}u_{t-2} + \pi_{15}u_{t-3} + \pi_{16}u_{t-6} + \cdots$$

$${}_{t-1}p_t = \pi_{21} + \pi_{23}u_{t-1} + \pi_{24}u_{t-2} + \pi_{25}u_{t-3} + \pi_{26}u_{t-4} + \cdots$$

$${}_{t}p_{t+1} = \pi_{21} + \pi_{23}u_t + \pi_{24}u_{t-1} + \pi_{25}u_{t-2} + \pi_{26}u_{t-3} + \cdots$$

$${}_{t-2}p_t = \pi_{21} + \pi_{24}u_{t-2} + \pi_{25}u_{t-3} + \pi_{26}u_{t-4} + \pi_{27}u_{t-5} + \cdots$$

$${}_{t-3}p_t = \pi_{21} + \pi_{25}u_{t-3} + \pi_{26}u_{t-4} + \pi_{27}u_{t-5} + \pi_{28}u_{t-6} + \cdots$$

$${}_{t-4}p_t = \pi_{21} + \pi_{26}u_{t-4} + \pi_{27}u_{t-5} + \pi_{28}u_{t-6} + \cdots$$

$${}_{t-5}p_t = \pi_{21} + \pi_{27}u_{t-5} + \pi_{28}u_{t-6} + \cdots$$

$${}_{t-6}p_t = \pi_{21} + \pi_{28}u_{t-6} + \cdots$$

$${}_{t-1}e_t = \pi_{31} + \pi_{33}u_{t-1} + \pi_{34}u_{t-2} + \pi_{35}u_{t-3} + \cdots$$

$${}_{t-2}e_t = \pi_{31} + \pi_{34}u_{t-2} + \pi_{35}u_{t-3} + \cdots$$

$${}_{t-3}e_t = \pi_{31} + \pi_{35}u_{t-3} + \pi_{36}u_{t-4} + \cdots$$

$${}_{t-4}e_t = \pi_{31} + \pi_{36}u_{t-4} + \pi_{37}u_{t-5} + \cdots$$

$${}_{t-5}e_t = \pi_{31} + \pi_{37}u_{t-5} + \pi_{38}u_{t-6} + \cdots$$

$${}_{t-6}e_t = \pi_{31} + \pi_{38}u_{t-6} + \pi_{39}u_{t-7} + \cdots$$

$$e_{t+1} = \pi_{31} + \pi_{32}u_{t+1} + \pi_{33}u_t + \pi_{34}u_{t-1} + \pi_{35}u_{t-2} + \cdots$$

$${}_te_{t+1} = \pi_{31} + \pi_{33}u_t + \pi_{34}u_{t-1} + \pi_{35}u_{t-2} + \cdots$$

Substituting into fundamental equations (3.1), (3.2) and (3.5), we get

$$d(\pi_{11} + \pi_{13}u_{t-1} + \pi_{14}u_{t-2} + \pi_{15}u_{t-3} + \pi_{16}u_{t-4} + \pi_{17}u_{t-5}$$

$$+ \pi_{18}u_{t-6} + \pi_{19}u_{t-7} + \ldots)$$

$$= d\bar{y} + (c_1 + c_2 + c_3 + c_4 + c_5 + c_6)\pi_{22}u_t$$

$$+ (c_2 + c_3 + c_4 + c_5 + c_6)\pi_{23}u_{t-1} + (c_3 + c_4 + c_5 + c_6)\pi_{24}u_{t-2}$$

$$+ (c_4 + c_5 + c_6)\pi_{25}u_{t-3} + (c_5 + c_6)\pi_{26}u_{t-4} + c_6\pi_{27}u_{t-5} + \cdots$$

$$(3.5')$$

$$-\pi_{21} + (1 - \pi_{22})u_t + (1 - \pi_{23})u_{t-1} + (1 - \pi_{24})u_{t-2}$$

$$+ (1 - \pi_{25})u_{t-3} + (1 - \pi_{26})u_{t-4} + (1 - \pi_{27})u_{t-5}$$

$$+ (1 - \pi_{28})u_{t-6} + \cdots$$

$$= b_0 - b_2 i^* + b_1\pi_{11} + [b_1\pi_{12} - b_2(\pi_{33} - \pi_{32})]u_t$$

$$+ [b_1\pi_{13} - b_2(\pi_{34} - \pi_{33})]u_{t-1} + [b_1\pi_{14} - b_2(\pi_{35} - \pi_{34})]u_{t-2}$$

$$+ [b_1\pi_{15} - b_2(\pi_{36} - \pi_{35})]u_{t-3} + [b_1\pi_{16} - b_2(\pi_{37} - \pi_{36})]u_{t-4}$$

$$+ [b_1\pi_{17} - b_2(\pi_{38} - \pi_{37})]u_{t-5} + [b_1\pi_{18} - b_2(\pi_{39} - \pi_{38})]u_{t-6}$$

$$+ [b\pi_{19} - b_2(\pi_{3,10} - \pi_{39})]u_{t-7} + \ldots$$

(3.2')

$$(1 - a_2)[\pi_{11} + \pi_{12}u_t + \pi_{13}u_{t-1} + \pi_{14}u_{t-2} + \pi_{15}u_{t-3} + \pi_{16}u_{t-4}$$

$$+ \pi_{17}u_{t-5} + \pi_{18}u_{t-6} + \ldots]$$

$$= a_0 - a_1 i^* + (a_9 + a_8 + a_7 + a_6 + a_5 + a_4 - a_3)(\pi_{31} - \pi_{21})$$

$$- a_{10}\bar{y} + [-a_1(\pi_{22} - \pi_{23}) - a_1(\pi_{33} - \pi_{32}) - a_3(\pi_{32} - \pi_{22})]u_t$$

$$+ [-a_1(\pi_{23} - \pi_{24} + \pi_{34} - \pi_{33})$$

$$+ (a_4 - a_3)(\pi_{33} - \pi_{23}) - a_{10}\pi_{13}]u_{t-1}$$

$$+ [-a_1(\pi_{24} - \pi_{25} + \pi_{35} - \pi_{34}) + (a_5 + a_4 - a_3)(\pi_{34} - \pi_{24})$$

$$- (a_{10} + a_{11})\pi_{14}]u_{t-2}$$

$$+ [-a_1(\pi_{25} - \pi_{26} + \pi_{36} - \pi_{35}) + (a_6 + a_5 + a_4 - a_3)(\pi_{35} - \pi_{25})$$

$$- (a_{10} + a_{11} + a_{12})\pi_{15}]u_{t-3}$$

$$\begin{aligned}
&+ [-a_1(\pi_{26} - \pi_{27} + \pi_{37} - \pi_{36}) + (a_7 + a_6 + a_5 + a_4 - a_3) \\
&\times (\pi_{36} - \pi_{26}) - (a_{10} + a_{11} + a_{12} + a_{13})\pi_{16}]u_{t-4} \\
&+ [-a_1(\pi_{27} - \pi_{28} + \pi_{38} - \pi_{37}) + (a_4 + a_5 + a_6 + a_7 + a_8 - a_3) \\
&\times (\pi_{37} - \pi_{27}) - (a_{10} + a_{11} + a_{12} + a_{13} + a_{14})\pi_{17}]u_{t-5} \\
&+ [-a_1(\pi_{28} - \pi_{29} + \pi_{39} - \pi_{38}) + (a_4 + a_5 + a_6 + a_7 + a_8 \\
&+ a_9 - a_3)(\pi_{38} - \pi_{28}) - (a_{10} + a_{11} + a_{12} + a_{13} + a_{14} \\
&+ a_{15})\pi_{18}]u_{t-6} + \cdots \qquad (3.1')
\end{aligned}$$

Equating the coefficients of same term u_{t-i} on both sides of equations (3.5'), (3.2') and (3.1'), we obtain the following.

From equation (3.5'), we get (C.2).

$$\begin{array}{lll}
\pi_{11} = c_0 & 0 = \pi_{22} & \pi_{13} = \frac{1}{d} A_2\pi_{23} \\
\pi_{14} = \frac{1}{d} A_3\pi_{24} & \pi_{15} = \frac{1}{d} A_4\pi_{25} & \pi_{16} = \frac{1}{d} A_5\pi_{26} \\
\pi_{17} = \frac{1}{d} A_6\pi_{27} & \pi_{18} = 0 & \pi_{19} = 0 \\
\cdots & & \qquad (C.2)
\end{array}$$

$$-\pi_{21} = b_0 - b_2 i^* + b_1 \pi_{11}$$

$$\pi_{12} = \frac{1}{b_1} [1 + b_2(\pi_{33} - \pi_{32})]$$

$$\pi_{23} = \frac{1 + b_2(\pi_{34} - \pi_{33})}{1 + b_1 \frac{A_2}{d}}$$

$$\pi_{24} = \frac{1 + b_2(\pi_{35} - \pi_{34})}{1 + b_1 \frac{A_3}{d}}$$

$$\pi_{25} = \frac{1 + b_2(\pi_{36} - \pi_{35})}{1 + b_1 \frac{A_4}{d}}$$

$$\pi_{26} = \frac{1 + b_2(\pi_{37} - \pi_{36})}{1 + b_1 \frac{A_5}{d}}$$

$$\pi_{27} = \frac{1 + b_2(\pi_{38} - \pi_{37})}{1 + b_1 \frac{A_6}{d}}$$

$$\pi_{28} = [1 + b_2(\pi_{39} - \pi_{38})]$$

$$\pi_{29} = [1 + b_2(\pi_{3,10} - \pi_{39})] \qquad (C.3)$$

where $A_2 = c_6 + c_5 + c_4 + c_3 + c_2$

$A_3 = c_6 + c_5 + c_4 + c_3$

$A_4 = c_6 + c_5 + c_4$

$A_5 = c_6 + c_5$

$A_6 = c_6$

From equation (3.1'), we obtain equations (C.4) - (C.10).

For term u_{t-6}, $(1-a_2)\pi_{18}$

$$= [-a_1(\pi_{28}-\pi_{29}+\pi_{39}-\pi_{38})+(a_9+a_8+\ldots+a_4-a_3)(\pi_{38}-\pi_{28})$$

$$-(a_{10}+a_{11}+a_{12}+a_{13}+a_{14}+a_{15})\pi_{18}] \quad (C.4)$$

For term u_{t-5}, $(1-a_2)\pi_{17}$

$$= [-a_1(\pi_{27}-\pi_{28}+\pi_{38}-\pi_{37})+(a_8+a_7+\ldots+a_4-a_3)(\pi_{37}-\pi_{27})$$

$$-(a_{10}+a_{11}+a_{12}+a_{13}+a_{14})\pi_{17}] \quad (C.5)$$

For term u_{t-4}, $(1-a_2)\pi_{16}$

$$= [-a_1(\pi_{26}-\pi_{27}+\pi_{37}-\pi_{36})+(a_7+a_6+a_5+a_4-a_3)(\pi_{36}-\pi_{26})$$

$$-(a_{10}+a_{11}+a_{12}+a_{13})\pi_{16}] \tag{C.6}$$

For term u_{t-3}, $(1-a_2)\pi_{15}$

$$= [-a_1(\pi_{25}-\pi_{26}+\pi_{36}-\pi_{35})+(a_6+a_5+a_4-a_3)(\pi_{35}-\pi_{25})$$

$$-(a_{10}+a_{11}+a_{12})\pi_{15}] \tag{C.7}$$

For term u_{t-2}, $(1-a_2)\pi_{14}$

$$= [-a_1(\pi_{24}-\pi_{25}+\pi_{35}-\pi_{34})+(a_5+a_4-a_3)(\pi_{34}-\pi_{24})$$

$$-(a_{10}+a_{11})\pi_{14}] \tag{C.8}$$

For term u_{t-1}, $(1-a_2)\pi_{13}$

$$= [-a_1(\pi_{23}-\pi_{24}+\pi_{34}-\pi_{33})+(a_4-a_3)(\pi_{33}-\pi_{23})-a_{10}\pi_{13}] \tag{C.9}$$

For term u_t, $(1-a_2)\pi_{12}$

$$= [-a_1(\pi_{22}-\pi_{23}+\pi_{33}-\pi_{32})-a_3(\pi_{32}-\pi_{22})] \qquad (C.10)$$

Using the solutions in (C.2) and (C.3), we can reduce equations (C.4) - (C.10) to second-order difference equations.

Let us solve equation (C.10) first. Since $\pi_{22} = 0$ in (C.2), $\pi_{12} = \frac{1}{b_1}[1 + b_2(\pi_{33} - \pi_{32})]$ and $\pi_{23} = \dfrac{1 + b_2(\pi_{34} - \pi_{33})}{1 + b_1\frac{A_2}{d}}$ in (C.3), equation (C.10) becomes as follows:

$$\frac{-a_1 b_2}{1 + b_1\frac{A_2}{d}}\pi_{34} + [(1 - a_2)\frac{b_2}{b_1} + \frac{a_1 b_1}{1 + b_1\frac{A_2}{d}} + a_1]\pi_{33}$$

$$+ [-(1 - a_2)\frac{b_2}{b_1} - a_1 + a_3]\pi_{32} = -(1- a_2)\frac{1}{b_1} + \frac{a_1}{1 + b_1\frac{A_2}{d}}$$

This is equation (B.2).

From Appendix B, we have proved that if the two characteristic roots are assumed to be greater unity in order to get a unique solution for π_{32}, the restrictions on a_3 are

$a_3 > 0$ if $k > 0$ (or $a_3 > 0$)

$$a_3 > \frac{2\{b_2[(1 - a_2)(1 + b_1\frac{A_2}{d}) + a_1b_1] + a_1b_1(1 + b_1\frac{A_2}{d})\}}{b_1(1 + b_1\frac{A_5}{d})}$$

If $k < 0$ (or $-a_3 < 0$)

The definition of k is in Appendix B.

Since the characteristic roots are greater than unity, the unique solution for π_{32} is its particular integral. For instance,

$$\pi_{32} = \beta_1(\lambda_1)^t + \beta_2(\lambda_2)^t + \bar{\pi}_{32}$$

If both $|\lambda_1|$ and $|\lambda_2|$ exceed 1, then $\beta_1 = \beta_2 = 0$ and $\pi_{32} = \bar{\pi}_{32}$.

Hence

$$\pi_{32} = \frac{(1 - a_2)(1 + b_1\frac{A_2}{d}) - a_1b_1}{-a_3b_1(1 + b_1\frac{A_2}{d})}$$

Similarly, we can get the restrictions on (a_4-a_3), $(a_5+a_4-a_3)$, $(a_6+a_5+a_4-a_3)$, . . . , $(a_9+a_8+a_7+a_6+a_5+a_4-a_3)$

and unique solutions for $\pi_{33}, \pi_{34}, \ldots, \pi_{38}$ from (C.9), (C.8), (C.7), . . . , (C.4), respectively. That is,

$$(a_4 - a_3) > 0 \quad \text{if } (a_4 - a_3) > 0 \text{ (or } k > 0)$$

$$(a_3 - a_4) > \frac{2(y + w + z)}{(1 + b_1^{\frac{A_2}{d}})(1 + b_1^{\frac{A_3}{d}})} \quad \text{if } (a_4 - a_3) < 0 \text{ (or } k < 0)$$

$$\pi_{33} = \frac{[(1 - a_2 + a_{10})^{\frac{A_2}{d}} + (a_4 - a_3)](1 + b_1^{\frac{A_3}{d}}) - a_1 b_1^{\frac{c_1}{d}}}{(a_4 - a_3)(1 + b_1^{\frac{A_2}{d}})(1 + b_1^{\frac{A_3}{d}})}$$

where

$$k = (a_4 - a_3)(1 + b_1^{\frac{A_2}{d}})(1 + b_1^{\frac{A_3}{d}}), \quad w = a_1 b_2 (1 + b_1^{\frac{A_2}{d}})$$

$$y = b_2[(1 - a_2 + a_{10})^{\frac{A_2}{d}} + a_1 + a_4 - a_3](1 + b_1^{\frac{A_3}{d}}),$$

$$z = a_1(1 + b_1^{\frac{A_2}{d}})(1 + b_1^{\frac{A_3}{d}}).$$

The above results are derived from equation (C.9).

$$(a_5 + a_4 - a_3) > 0 \quad \text{if } k > 0 \text{ (or } a_5 + a_4 - a_3 > 0)$$

$$(a_3 - a_4 - a_5) > \frac{2(y + w + z)}{(1 + b_1^{\frac{A_2}{d}})(1 + b_1^{\frac{A_3}{d}})}$$

if $k < 0$ (or $a_5 + a_4 - a_3 < 0$)

$$\pi_{34} = \frac{[(1 - a_2+a_{10}+a_{11})^{-\frac{A_3}{d}} + a_5+a_4-a_3](1 + b_1^{-\frac{A_4}{d}}) - a_1 b_1^{-\frac{c_3}{d}}}{(a_5 + a_4 - a_3)(1 + b_1^{-\frac{A_3}{d}})(1 + b_1^{-\frac{A_4}{d}})}$$

where

$$k = (a_5 + a_4 - a_3)(1 + b_1^{-\frac{A_3}{d}})(1 + b_1^{-\frac{A_4}{d}}),$$

$$w = a_1 b_2 (1 + b_1^{-\frac{A_3}{d}}),$$

$$y = b_2[(1 - a_2+a_{10}+a_{11})^{-\frac{A_3}{d}} + a_1+a_5+a_4-a_3](1 + b_1^{-\frac{A_4}{d}}),$$

$$z = a_1(1 + b_1^{-\frac{A_3}{d}})(1 + b_1^{-\frac{A_4}{d}}).$$

The above results are derived from equation (C.8).

$(a_6+a_5+a_4-a_3) > 0$ if $k > 0$ [or $(a_6+a_5+a_4-a_3) > 0$]

$$(a_3 - a_4 - a_5 - a_6) > \frac{2(y + w + z)}{(1 + b_1^{-\frac{A_4}{d}})(1 + b_1^{-\frac{A_5}{d}})}$$

if $k < 0$ (or $a_6 + a_5 + a_4 - a_3 < 0$)

$$\pi_{35} = \frac{[(1 - a_2+a_{10}+a_{11})^{-\frac{A_4}{d}} + a_6+a_5+a_4-a_3](1 + b_1^{-\frac{A_5}{d}}) - a_1 b_1^{-\frac{c_4}{d}}}{(a_6 + a_5 + a_4 - a_3)(1 + b_1^{-\frac{A_4}{d}})(1 + b_1^{-\frac{A_5}{d}})}$$

where

$$k = (a_6 + a_5 + a_4 - a_3)(1 + b_1^{\frac{A_4}{d}})(1 + b_1^{\frac{A_5}{d}}),$$

$$w = a_1 b_2 (1 + b_1^{\frac{A_4}{d}}),$$

$$y = b_2[(1 - a_2 + a_{10} + a_{11} + a_{12})^{\frac{A_4}{d}} + a_1 + a_6 + a_5 + a_4 - a_3](1 + b_1^{\frac{A_5}{d}}),$$

$$z = a_1 (1 + b_1^{\frac{A_4}{d}})(1 + b_1^{\frac{A_5}{d}}).$$

The above results are derived from equation (C.7).

$$a_7 + a_6 + a_5 + a_4 - a_3 > 0$$

$$\text{if } k > 0 \text{ [or } a_7 + a_6 + a_5 + a_4 - a_3 > 0]$$

$$a_3 - a_4 - a_5 - a_6 - a_7 > \frac{2(y + w + z)}{(1 + b_1^{\frac{A_5}{d}})(1 + b_1^{\frac{A_6}{d}})} \text{ if } k < 0$$

$$\pi_{36} = \frac{[(1 - a_2 + a_{10} + a_{11} + a_{12} + a_{13})^{\frac{A_5}{d}} + a_7 + a_6 + a_5 + a_4 - a_3] (1 + b_1^{\frac{A_6}{d}}) - a_1 b_1^{\frac{c_5}{d}}}{(a_7 + a_6 + a_5 + a_4 - a_3)(1 + b_1^{\frac{A_5}{d}})(1 + b_1^{\frac{A_6}{d}})}$$

where

$$k = (a_7 + a_6 + a_5 + a_4 - a_3)(1 + b_1^{\frac{A_5}{d}})(1 + b_1^{\frac{A_6}{d}}),$$

$$w = a_1 b_2 (1 + b_1^{\frac{A_5}{d}}),$$

$$y = b_2[(1 - a_2 + a_{10} + a_{11} + a_{12} + a_{13})^{\frac{A_5}{d}} + a_1 + a_7 + a_6 + a_5 + a_4 - a_3]$$

$$x\ (1 + b_1^{\frac{A_6}{d}}),$$

$$z = a_1 (1 + b_1^{\frac{A_5}{d}})(1 + b_1^{\frac{A_6}{d}}),$$

The above results are derived from equation (C.6).

$$a_8 + a_7 + a_6 + a_5 + a_4 - a_3 > 0 \text{ if } k > 0$$

$$a_3 - a_4 - \ldots - a_8 > \frac{2(y + w + z)}{(1 + b_1^{\frac{A_6}{d}})} \text{ if } k < 0$$

$$\pi_{37} = \frac{[(1 - a_2 + a_{10} + a_{11} + a_{12} + a_{13} + a_{14})^{\frac{A_6}{d}} + a_8 + a_7 + a_6 + a_5 + a_4 - a_3] - a_1 b_1^{\frac{A_6}{d}}}{(a_8 + a_7 + a_6 + a_5 + a_4 - a_3)(1 + b_1^{\frac{A_6}{d}})}$$

where

$$k = (a_8 + \ldots + a_4 - a_3)(1 + b_1\frac{A_6}{d}),$$

$$w = a_1 b_2(1 + b_1\frac{A_6}{d}),$$

$$y = b_2[(1-a_2+a_{10}+a_{11}+a_{12}+a_{13}+a_{14})\frac{A_6}{d} + a_1+a_8+a_7+a_6+a_5+a_4-a_3],$$

$$z = a_1(1 + b_1\frac{A_6}{d}),$$

The above results are derived from equation (C.5).

$$(a_9 + a_8 + a_7 + \ldots + a_4 - a_3) > 0 \text{ if } k > 0$$

$$(a_3 - a_4 - \ldots - a_9) > 2(y + w + z) \quad \text{if } k < 0$$

$$\pi_{38} = 1.$$

where

$$k = (a_9 + a_8 + \ldots + a_4 - a_3),\ w = a_1 b_2,$$

$$y = b_2(a_1 + a_9 + \ldots + a_4 - a_3],\ z = a_1,$$

The above results are derived from equation (C.4).

After getting the unique solution from (C.10) - (C.4) and substituting the solution back to (C.2) and (C.3), we get the unique solution for π_{11}, π_{13}, . . . , π_{21}, π_{22}, π_{23}, ...

If we set $\pi_{11} = y_0$, $\pi_{12} = \alpha_1, \ldots, \pi_{17} = \alpha_6$, $\pi_{21} = p_0$, $\pi_{22} = \beta_1 = 0$, $\pi_{23} = \beta_2, \ldots, \pi_{27} = \beta_6$, $\pi_{28} = \beta_7 = 1$, $\pi_{31} = e_0$, $\pi_{32} = f_1, \ldots, \pi_{37} = f_6$, $\pi_{38} = f_7 = 1, \ldots$, then we get the reduced-form solution (3.6), (3.7) and (3.8). Substituting (3.6), (3.7), (3.8) or (3.4) into (3.3), (3.6), and the trade balance part of (3.1), we get the reduced-form solution for i_t, w_t, T_t, that is (3.9), (3.10) and (3.11). Finally, we obtain the general solution in section 3.3.

APPENDIX D
TRADE BALANCE ADJUSTMENTS

Table D.1. The trade balance following the devaluation of the Korean won in December 1974 (unit: billions of won).

Country	Korea, Rep. of	Currency	won
Date of devaluation	Dec. 1974	Rate of devaluation	20%

Year	1974				1975			
Quarter	I	II	III	IV	I	II	III	IV
Period	-3	-2	-1	0	1	2	3	4
Trade Balance	-151	-196	-211	-272	-391	-313	-9	-95
Year	1976				1977			
Quarter	I	II	III	IV	I	II	III	IV
Period	5	6	7	8	9	10	11	12
Trade Balance	-178	-82	-27	2	-54	-230	22	29
Year	1978				1979			
Quarter	I	II	III	IV	I	II	III	IV
Period	13	14	15	16	17	18	19	20
Trade Balance	-124	-216	-238	-385	-492	-734	-445	-458

Sources: International Financial Statistics, I.M.F.

Table D.2. The trade balance following the devaluation of the U.K. pound sterling in November 1967 (unit: millions of pounds sterling).

Country	United Kingdom				Currency		pound sterling	
Date of devaluation	Nov. 1967				Rate of devaluation		14.3%	
Year	1967				1968			
Quarter	I	II	III	IV	I	II	III	IV
Period	-3	-2	-1	0	1	2	3	4
Trade Balance	-75	-87	-123	-270	-213	-181	-178	-71
Year	1969				1970			
Quarter	I	II	III	IV	I	II	III	IV
Period	5	6	7	8	9	10	11	12
Trade Balance	-182	-10	-1	52	38	-42	-102	118
Year	1971				1972			
Quarter	I	II	III	IV	I	II	III	IV
Period	13	14	15	16	17	18	19	20
Trade Balance	-137	136	151	153	-211	-33	-335	-118

Sources: International Financial Statistics, I.M.F.

Table D.3. The trade balance following the devaluation of the Nepalese rupee in October 1975 (unit: millions of rupees).

Country	Nepal	Currency	rupee
Date of devaluation	Oct. 1975	Rate of devaluation	18.4%

Year	1975				1976			
Quarter	I	II	III	IV	I	II	III	IV
Period	-3	-2	-1	0	1	2	3	4
Trade Balance	-294	-226	9	-188	-288	-143	-52	-203

Year	1977				1978			
Quarter	I	II	III	IV	I	II	III	IV
Period	5	6	7	8	9	10	11	12
Trade Balance	-204	-259	-230	-304	-408	-368	-376	-308

Sources: International Financial Statistics, I.M.F.

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BIOGRAPHICAL SKETCH

Van-Jeou Chen was born in Pingtung, Taiwan, in March 1949. He earned his B.A. and M.A. in economics at Soochow University in Taiwan in 1971 and 1974. Three Papers on Special Drawing Rights was his master's thesis which received the second prize in "The 1977 Contest of Youth's Writing and Invention" sponsored by the Ministry of Education of the Republic of China. During 1974-76, he served as a Second Lieutenant in the First NCO Army School of the Republic of China. He was an instructor in economics at Fung-Chia University in Taiwan during 1976-79 and 1981-82. In 1982, he reentered the Graduate School of the University of Florida, where he is completing his Ph.D. in economics.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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Insurance and Real Estate

This dissertation was submitted to the Graduate Faculty of the Department of Economics in the College of Business Administration and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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